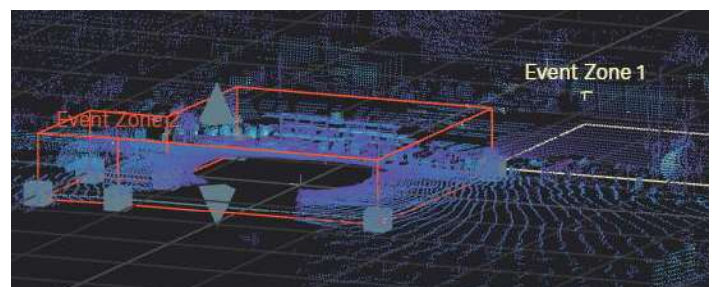
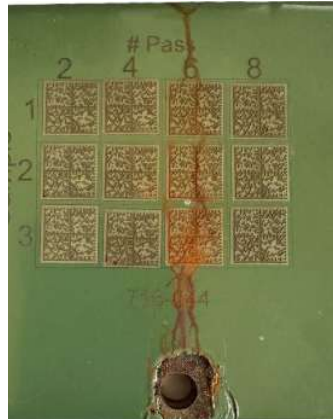
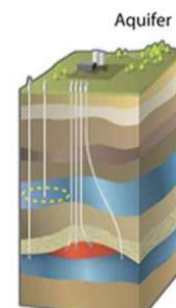
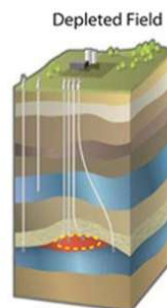
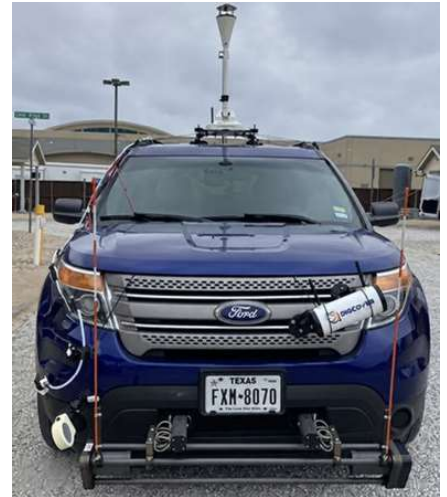
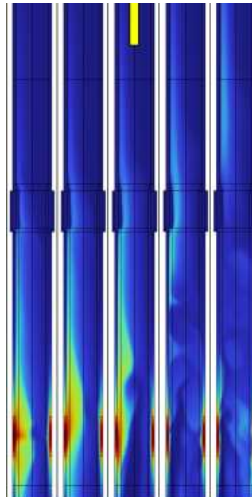


RESEARCH PROJECT SUMMARIES 2025



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Operations Technology Development, NFP

RESEARCH PROJECT SUMMARIES

2025

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Chairman / President's Letter

The gas pipeline and storage network provides a vital link in delivering energy to millions of homes, businesses, and industrial customers. Supporting the safety, efficiency, and reliability of this infrastructure is Operations Technology Development (OTD), a nonprofit collaborative organization representing 31 member companies serving more than 70 million customers across the U.S., Canada, and France.

OTD's work plays a critical role in driving innovation and research that strengthens the safety, performance, and resilience of the gas system. In 2025, our research and development efforts were guided by a clear vision: to advance practical technologies that help operators meet growing operational demands, apply artificial intelligence (AI) responsibly and effectively, and better understand how evolving energy-use patterns influence infrastructure planning and operations.

Throughout our project portfolio, we remained committed to advancing solutions that address today's challenges while anticipating tomorrow's needs. A central part of this approach is fostering a collaborative environment that encourages open sharing of challenges and collective problem solving. By working together, we accelerate insights, identify practical solutions, and integrate learnings more effectively across operations.

Our initiatives in 2025 spanned a wide range—from reinforcing safety in field and system operations and streamlining work processes, to improving data-driven decision making, advancing leak management tools and practices, and applying AI to monitoring, forecasting, and asset management. Other efforts focused on helping operators understand and plan for shifting load patterns tied to new large energy users, industrial growth, and emerging flexible demands. These projects reflect OTD's belief that innovation is most impactful when it enhances safe operations, supports practical efficiency, and strengthens long-term energy resilience.

This report summarizes more than 100 projects within OTD's 2025 program and highlights several significant achievements. Taken together, these efforts form a cornerstone of the industry's ongoing success in delivering safe, reliable, resilient, and affordable energy.

We appreciate your interest in our project portfolio and look forward to continued progress in the years ahead.

OTD Members

- > Ameren Illinois
- > APGA Research Foundation
- > Atmos Energy Corporation
- > Avista Utilities
- > Blackhills Energy
- > Consolidated Edison Co. of NY, Inc./ Orange & Rockland Utilities, Inc.
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- > Exelon
- > GDRF
- > MDU
 - Cascade
 - Intermountain Gas Company
- > Liberty Utilities
- > Louisiana RDC
 - Atmos Energy Corporation
 - Delta Utilities
- > National Fuel Gas Distribution Corporation
- > National Grid
- > New York State Electric & Gas Corp. / Rochester Gas and Electric
- > Nicor Gas
- > NiSource Inc.
- > NW Natural
- > Oklahoma Natural Gas
- > Pacific Gas and Electric Company
- > Peoples Gas
- > Southern California Gas Co., a Sempra Energy Utility
- > Southwest Gas Corporation
- > Spire (Alabama)
- > TECO Peoples Gas

Chair of the Board

Pat Whiteside



President

Ron Snedic



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Results in Use

Since 2003, the OTD program has provided utilities, pipeline companies, service providers, and others in the natural-gas-delivery business with innovative tools, enhanced processes, and advanced equipment for improving gas system operations.

These products represent the results of OTD efforts to build a stronger industry infrastructure, enhance system integrity, and improve the efficiency of a wide range of operations activities.

Selected OTD-Developed Products in the Marketplace



Jameson Directional Entry Tool and Live Tracer

Jameson, a Spartaco Company

This directional tool enables vertical insertion of tracer rods and cameras into live gas mains, facilitating the difficult first bend of the entry. It operates on live mains with no blow by and is compatible with keyhole procedures (fits 24-in minimum keyhole). The tool can be used on mains as small as two inches in diameter; rotates 360 to insert in either direction; and fits most camera heads.

Contact: Tim Beed

803-222-8400

tbeed@spartacoGroup.com

www.jamesonllc.com



Kleiss MCS Flow Stopping System

Mainline Control Systems

The Kleiss MCS Flow Stopping System is used to stop the flow of gas in polyethylene, steel, cast-iron, and PVC pipes at diameters up to 18-in and pressures up to 60 psig. The system, which is manufactured in Europe, was investigated through OTD to validate its operation and potential savings in the U.S. gas industry.

844-356-7867

www.mainlinecontrolsyste.ms.com



Portable Methane Detector (PMD)

SENSIT Technologies

This handheld SENSIT® PM uses optical detection to provide sensitivity and cost advantages over conventional techniques employing flame ionization detectors. The PMD provides the efficiency of leak surveys, is less costly to maintain than other technologies, and can detect leaks from low ppm to 100% gas.

Contact: Scott Kranstuber

440-482-9539

skranstuber@gasleaksensors.com

info@gasleaksensors.com



IRED Infrared Portable Ethane Detector

SENSIT Technologies

This easy-to-use handheld detector was developed for use in the field to discriminate natural gas leaks from other sources of methane (e.g., swamp gas, landfill gas, and engine exhaust) and detect trace levels of ethane. The detection of ethane can be used as a fingerprint for natural gas in situations where the origin of a methane leak signal is questioned.

Contact: Scott Kranstuber

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info@gasleaksensors.com



LocusIQ for Intelligent Inspections

LocusView/Itron

A software platform developed through OTD is now part of the LocusView mobile product suite to allow users to collect new installation data directly within a GIS environment. Applications to integrate real-time, sub-foot accurate GPS and barcode scanning are included.

Contact: Alicia Farag
847-387-9412
Alicia.Farag@itron.com
www.itron.com



LocusMap Mobile GIS Solution

LocusView/Itron

This system maps new installations with comprehensive tracking and traceability data, creating GIS features in a format that allows field-collected data to be directly integrated into the enterprise GIS. Barcode scanning and high-accuracy GPS automate the system and help create high-accuracy maps.

Contact: Alicia Farag
847-387-9412
Alicia.Farag@itron.com
www.itron.com

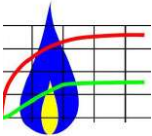


LocusSurvey for Tracking Leak-Survey Routes

LocusView/Itron

LocusSurvey uses tablet computers and GPS to track leak-survey routes. The GPS breadcrumb trail is overlaid in a GIS to track pipe segments that are surveyed to provide real-time reporting and monitoring. LocusSurvey eliminates paper maps and records, automating the process of documenting surveys and leak locations.

Contact: Alicia Farag
847-387-9412
Alicia.Farag@itron.com
www.itron.com



GASPurge™ Program Update

B3PE

GASPurge™ is a web-based application for planning pipeline purging and clearing operations, including estimating gas used, gas lost, and purge time. Developed in collaboration with and distributed under license of GTI Energy.

Contact: Bradley Bean
719-578-9391
sales@b3pe.com



Synergi Pipeline Simulator

DNV GL

DNV GL's pipeline integrity software, Synergi Pipeline, is a scalable company-wide risk- and integrity-management system. It enables safe and efficient pipeline operations, documents risk, and provides users, including upper management, with a clear overview of the integrity of distribution networks and offshore and onshore pipelines.

Contact: Michael Moore
717-724-1900
michael.moore@gl-group.com
www.dnvgl.com



Lift Assists for Pavement Breakers and Rock Drills

Makinex

These devices assist workers in lifting pavement breaker and rock drills after the bits break through surface pavements and rocks and need to be repositioned for the next penetration. By eliminating the need to manually lift and re-position the heavy tools, the lift assists make breaking easier and less physically demanding.

Contact: Ted Drechsel
t.drechsel@makinex.com
www.integratedtoolsolutions.com



HaloValve Breakaway Device

OPW Engineering Systems

When a natural gas line is broken or breached at the meter set assembly, an uncontrolled natural gas leak occurs. Upon a hard impact, the HaloValve breakaway immediately seals until the line can be repaired.

Contact: David Jacobson

513-816-2769

david.jacobson@opwglobal.com

www.halovalve.com



Keyhole Pipeline Inspection Camera System

ULC Robotics

The PRX250K keyhole camera is an internal inspection system designed for visual assessment of live mains through conventional pits or small keyholes. The system is easily maneuverable through tight bends, allowing utilities to examine pipe segments without the need to drill additional access holes.

Contact: Ryan McGowan

631-667-9200

ryan.mcgowan@spx.com

https://ulctechnologies.com



Live Gas Mapping

Reduct

The ability to enter live gas pipes eliminates downtime during the mapping procedure, meaning there is no disruption in service to your customers. This probe can map buried live gas transmission and distribution pipelines.

Contact: Otto Ballintijn

Otto.Ballintijn@reduct.net

https://reduct.net/



Hathorn Inspection Gas Camera

Hathorn

The system was designed as a way for utilities to inspect live gas mains through 90-degree keyhole pipe entries. The Hathorn Inspection Camera can inspect 2-6-in gas mains while recording inspections to USB or HDD.

Contact: Rob Luck

1-905-604-7040

rob@hathorncorp.com

www.hathorncorp.com



Material Traceability - Unique Identifier (ASTM F2897)

PPI

The standard ensures consistent, interoperable traceability across the gas distribution industry, supporting safety, quality control, and regulatory compliance.

This specification remains the primary reference for traceability encoding in natural gas distribution components. It establishes a uniform tracking and traceability encoding system for natural gas distribution components. It is a standard that defines a base-62, 16-character traceability code used to identify natural gas distribution components, including manufacturer, lot code, production date, material, size, and component type.

Contact: Dr. Randy Knapp

469-499-1054

rknapp@plasticpipe.org



PA12 piping systems

PA12

PA12 piping systems, provide a corrosion-resistant, high-pressure plastic alternative to steel for natural gas distribution operating up to 250 psi. With its superior impact resistance, anti-corrosion properties, and resistance to chemicals and heavy hydrocarbons, PA12 ensures long-term safety and reliability without the need for costly monitoring or maintenance. Additionally, its ease of installation and compatibility with existing PE fusion equipment streamline deployment, delivering significant savings in time, labor, and resources.

Contact: Douglas Weishaar
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704-206-9801

Informational Products

In addition to the development of new tools, processes, and products, OTD supports research that results in useful information on various aspects related to gas delivery and operations. Listed here are some of the key reports developed under OTD sponsorship.

Selected OTD-Developed Technical Reports



RFID Marker Technology Implementation Guidelines

A set of guidelines was developed for the implementation and application of integrated Global Positioning Systems (GPS), Geographic Information Systems (GIS), and “Smart Tag” technologies to streamline public-improvement project planning and prevent damage caused by excavations.



Cross Bores Best Practices Guide & Video

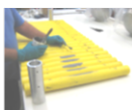
Significant research was conducted to investigate gas line/sewer line cross bores. The Guide and “how-to” videos (available through the OTD website) provide recommendations and procedures for preventing and detecting cross bores. (OTD-12/0003)



Residential Methane Gas Detector Program

This report provides results of a project initiated to determine whether commercially available combustible gas detectors are susceptible to giving false positive responses to an assortment of typical household chemicals, including ammonia, ethanol, acetone, toluene, isobutane, ethyl acetate, isopropanol, heptane, and hydrogen. (OTD-13/0003)

PIPE MATERIALS, REPAIR & REHABILITATION



Repair Wrap for Polyethylene (PE) Systems

Researchers evaluated a new composite pipe wrap system for the repair of mechanically damaged polyethylene gas pipe. The repair system has the potential to lower repair costs, reduce repair times, and minimize disruptions. (OTD-17/0001)



Liners/Composites for the Rehabilitation of Distribution and Transmission Lines

A report titled Transmission Infrastructure Roadmap was prepared to address the implementation of composite piping materials in the rehabilitation of gas transmission systems. This report includes information on composite pipes, trenchless repairs, and cured-in-place structural liners.



Evaluation of Structural Liners for the Rehabilitation of Liquid and Natural Gas Piping Systems

This report details the results of testing conducted to evaluate the long-term performance of liners and composites used in trenchless operations for the rehabilitation of aging gas distribution and transmission lines.



Polyurea Coating Testing and Assessment for Gas-Industry Use

A final report is available on research into field-applied polyurea coatings for gas industry use. Through a new initiative, long-term field trials will be conducted to evaluate these additional coatings and determine a cost-effective coating-application method and process.



Electrofusion Coupling Evaluation and Best Practices

Researchers investigated techniques used to perform electrofusion joining of plastic gas pipe in an effort to develop guidelines for the use and operation of electrofusion coupling. With a detailed set of guidelines, the gas industry can enhance the performance and safety of its plastic piping systems.



Intelligent Utility Installation Process

This report provides a methodology, field process, and a data model for capturing data during new utility installations. The process is used to capture information regarding the location, materials, installation process, environmental considerations, and other factors. (OTD-12/0002)



Tracer Wire for HDD Applications

Extensive research and testing culminated in the release of a report that provides valuable information on the properties and performance of various tracer-wire products for use in horizontal directional drilling (HDD) operations. (OTD-13/0001)



Enterprise Decision Support System

This report presents the results of efforts to create a technology roadmap for the development of an Enterprise Decision Support System to integrate gas-system data and knowledge from various sources into a single information source to support decision making.



Assessment of Vehicle-Barrier Design for Aboveground Facility Protection

Investigators compiled the latest information on the design, regulations, and installation practices of structural vehicle barriers used to protect aboveground utility facilities from vehicular damages. The Final Report also includes a review of various state and federal safety guidelines.



Study of Low-Impact Markings

A variety of paints, materials, and techniques were tested and characterized in an effort to identify products and methods that can be used for temporary utility marking. Information developed in this study allows users to identify the most appropriate marker type for a given environment to achieve the desired marking duration. (OTD-11/0002)



Solar-Powered Remote Monitoring

In this study, solar-powered devices were investigated as power sources for the remote monitoring of various gas utility facilities to more cost-effectively obtain rectifier data, pipe-to-soil measurement, pipe-to-casing readings, and other information.



Integrating GPS into Routine Operations

This report provides a set of recommendations and GPS implementation strategies developed through pilot programs, literature searches, and reviews of existing applications. Operations that were considered included meter reading, leak surveying, new installations, corrosion monitoring, and valve inspections.



DVDs for Training First Responders

DVD training products help gas companies better educate first-responding personnel about natural gas emergencies. Learning modules with realistic scenarios cover a variety of issues to enhance public and worker safety. The product also serves to improve emergency-response effectiveness and coordination.



Tracking and Traceability Standards

ASTM F2897 "Standard Specification for Tracking and Traceability Encoding System of Natural Gas Distribution Components (Pipe, Tubing, Fittings, Valves, and Appurtenances)" was developed in part by OTD, and adopts the world's most used product identification standard GS1.



Data Collection, Normalization and Integration Methods to Enhance Risk Assessment Tools for Decision Making

Co-Funded by PHMSA, this project looked to create methods and software tools to help operators of natural gas pipelines better estimate risks and improve risk-mitigation decisions.



Pull Load Calculator

The WEAKLINKapp allows trenchless contractors and field personnel to select an appropriate weak link so that trenchless installed HDPE and MDPE gas pipes are not overstressed during their installation. It also allows field personnel to determine if the weak link being used on a job, is in accordance with the GTI Horizontal Directional Drilling Weak Links report, federal regulations, and weak link requirements.

METHANE EMISSIONS/DETECTION & GAS QUALITY



Siloxane Concentrations in Biomethane

Biomethane from various waste products could provide consumers with a significant source of "green" renewable energy. In efforts to help develop this green resource, a study was conducted into siloxane – one of the potential constituents in biomethane – to assess its influence on health, the environment, and gas-fired appliances.



Field Measurement Program to Improve Uncertainties for Key Greenhouse Gas Emission Factors for Distribution Sources

This report summarizes the results of field surveys conducted at six natural gas utilities. With the support of the American Gas Association, research updated emissions factors for metering stations, regulating stations, and customer meters. (OTD-10/0002)



Improving Methane Emission Estimates for Natural Gas Distribution Companies

This report details Phase 2 of a four-phase field-testing program to evaluate gas leak rates from belowground pipelines, provide a simplified procedure that can be used to monitor pipeline leaks from surface measurements, and update the methane emission estimates for the main lines in a distribution system.



Pipeline-Quality Methane: North American Guidance Document for Introduction of Dairy-Waste-Derived Biomethane into Existing Natural Gas Networks

The guidance document provides reference and recommendations for the consideration of biomethane from dairy-waste digestion for introduction into gas pipeline networks. The report details results of a biogas/biomethane Gas Technology Institute research program.



Standard for Siloxane Content in Biomethane

The purpose of this project was to develop, in conjunction with ASTM Committee D03 on Gaseous Fuels, an industry-wide sampling and analysis standard for measuring siloxanes in biomethane that could obtain a detection limit of 0.01 mg/M3 of silicon or less. Work resulted in a new ASTM standard test method D8230-19 "Standard Test Method for Measurement of Volatile Silicon-Containing Compounds in a Gaseous Fuel Sample Using Gas Chromatography with Spectroscopic Detection" to be created and published in 2019.

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CONSTRUCTION/ INFRASTRUCTURE

Addressing issues often beyond the traditional areas, this research involves the development of tools and techniques for metering, gas shutoff, remote monitoring, cathodic protection, data collection, and other applications.

Developed technologies are subjected to a regimen of laboratory and field evaluations to ensure their safety and efficiency.

Efforts include projects to enhance and broaden the knowledge base for plastic pipe materials, virtual reality training, development of technology for remote service abandonment without excavation, cybersecurity, addressing gas odor fade, and re-development of underground piercing tools.

REMS Phase 3: Development of field Ready Prototype

Researchers will develop a field-ready prototype system for isolating 20-in diameter low pressure mains through 2-in PE service line access, eliminating the need for excavation. The Remote Emergency Main Shutoff (REMS) system enables crews to deploy an inflatable stopper through existing service lines, reducing response time, lowering costs, and minimizing risks to workers and facilities.

Project Description

The goal of this project is to build on the lessons learned from the prototypes developed and tested for the previous phases of OTD project 5.16.d and develop a field-ready prototype system that can successfully deploy a custom 20-in inflatable stopper into a 20-in main through 2-in PE service line pipe consisting of a full port ball valve, an electrofusion fitting, and a street tee fitting. This configuration was decided upon based on results found during the previous phase.

Deliverables

Deliverables for this project included a lab-tested prototype, a field-ready, sponsor-approved, procedure for field crews to follow, and a final report.

Benefits

Large diameter low pressure mains typically do not have shutoff valves installed which can be used to isolate sections of main. During emergency incidents local distribution companies are often tasked to expose, tap, and install inflatable stoppers on either side of a leaking main to isolate the flow of gas. These activities can be lengthy and costly. The ability to isolate large diameter mains without needing to excavate will save time, reduce cost, reduce

facility damage risk, reduce worker injury risk, and will reduce negative impacts to customers.

Technical Concept & Approach

Specific tasks in this project include:

Product Enhancements

The work in this task includes further development and enhancement of the prototype system from Phase 2. The team will construct multiple enhanced inflatable balloon stoppers (addressing known issues from Phase 2) and assemble the entire prototype with the calculated length segments. Additionally, the team will make a new stuffing box with service line seal and develop a nitrogen inflation system (with gauges).

Product Testing in Lab

The work in this task includes testing and refining the prototype system and procedure by deploying the revamped Phase 2 inflatable balloon stopper to validate the minimum required length, identify the proper range of service lengths, evaluate how to determine when the balloon stopper is sufficiently in the main without seeing inside the service or main, and determine the number of cable unwraps which are required pre-inflation to prepare the balloon stopper for inflation. Additionally, an infla-



New stuffing box design



Downstream cap containing flowmeter and camera



Flowmeter



Polyurethane bags of different thicknesses for testing

tion procedure with nitrogen will be developed to investigate how much pressure to use, determine how long the process takes, and see how pressure gauges can be implemented. A removal process will also be developed to be able to deflate and retrieve the stopper from the main. Lastly, the team will identify and/or select live gas camera systems to be used before deployment and test the use of these systems on the specified service line configuration.

Procedure Writing (Go/No-Go step)

With approval to move forward from project sponsors based on previous results, this task includes developing documented field procedures for deploying the system; with assistance, input, and review from the project sponsors.

Results/Status

The project team finalized the design of the 20-in REMS Phase 3 Inflation Bag with the bag manufacturer. The bag manufacturer produced multiple prototypes which were then assembled by the project team. The team modified the design of the Stuffing Box to better seal around the push cable and identified an inline flow meter to use to determine what volume of air is needed to properly inflate the 20-in REMS Phase 3 Inflation Bag to seal the 20-in steel pipe.

Testing confirmed that the flow meter totalizer was able to measure the correct volume required to inflate the bag to fill the 20-in steel pipe. The exact volume of the inflated bag with the associated tubing was determined by measuring the air that passed through the totalizer.

The project team installed 20-in end caps onto the 20-in steel test pipe. The end caps allowed the pipe to be pressurized to 7-in W.C and were equipped with ports that allowed installation of a camera and flowmeter. The camera allowed the project team to get a live view inside the pipe to monitor the installation and inflation of the bags. The flowmeter measured any leakage once the bags were installed and fully inflated.



Service line configuration including 2-in PE piping, elbow and ball valve.

Testing was initially performed using 10 mil thick bags. The bags were inserted into the 20-in pipe and inflated. Inflation was monitored using the camera installed through the end cap. After the bags were fully inflated the flowmeter port on the end cap was opened and flow was recorded. Flow stabilized at 13 scfh indicating there was a small leak across the bags.

The system was modified to use thicker 12 mil thick bags, and the test was rerun. After the 12 mil thick bags were fully inflated a flow of 0 scfh was recorded indicating there was no detectable leak across the bags.

Status

This project is complete and a Final Report was issued in December 2025. Additional trials in the field should be performed in the next phase of development to test if it is useful in real world configurations of service piping. Future potential improvements were identified during this phase of development. Improvements the team has identified would further reduce leakage from the stuffing box and reduce the time required to deflate the bag which would minimize the time spent in the customer residence. If the REMS system was commercialized, it would also need to be available in a variety of lengths.

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Material-Supplier Quality Assurance Program

Researchers will update 20 standardized purchasing specifications and the quality manual developed in an earlier phase, incorporating recent changes in codes and standards, operator feedback, and quality audit findings, and will support operators in deploying these documents within their organizations. The enhanced specifications will reduce variability in manufacturing processes, improve product quality, and give operators clearly defined purchasing requirements that go beyond the minimum requirements of codes and industry standards.

Project Description

The project will update and improve 20 purchasing specifications and the quality manual previously created, based on recent changes in codes and standards, feedback from operators, and quality audit findings. The team will also receive feedback from operators on the success and challenges of implementing the enhanced purchasing specifications and provide assistance where needed for deployment.

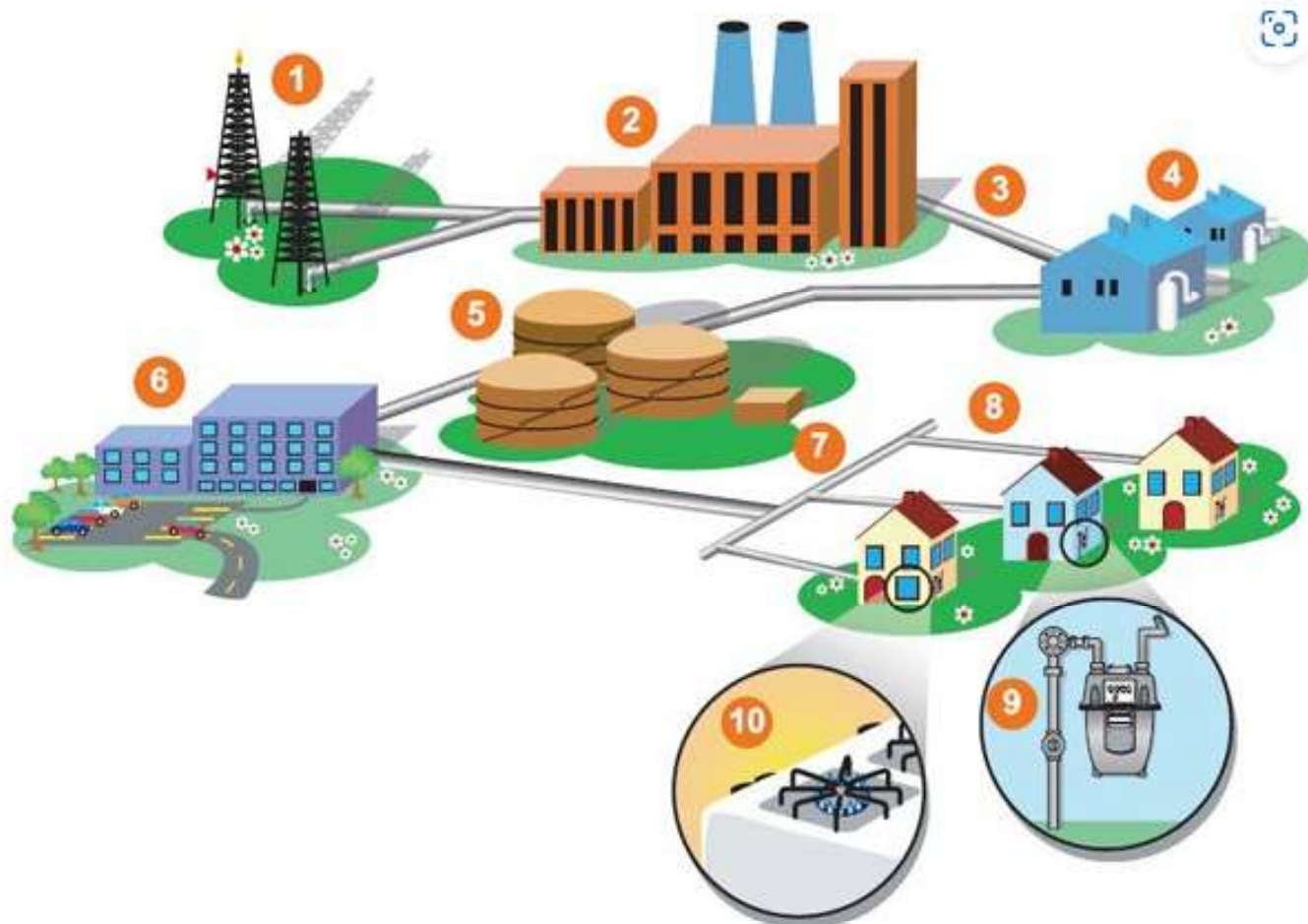
In Phase I of this project, 22 purchasing specifications were created along with a Supplier Quality Manual and 8 quality procedures for operators' internal use. The 22 purchasing specifications cover the following product families: Anodeless Risers, Diaphragm Meters, Excess Flow Valves, FBE Coating, Flanges and Accessories, Forged Steel Threaded Fittings, Forged Branch Outlet Fittings, Malleable Iron Threaded Fittings, Mechanical Steel Fittings, Thermoplastic Shutoffs and Valves, PE EF Fittings, PE Heat Fusion Fittings, Plastic Mechanical Fittings, Plastic Pipes, Rotary Meters, Service Regulators, Steel Pipes, Steel Valves, Steel Weldable Fittings, Transition Fittings, Valves up to 2-in, and Wrought Butt Welding Fittings. The 8 quality procedures include a Supplier Quality Manual, Supplier Performance Evaluation, Supplier Selection and Qualification, Calibration and Verification Procedure, Control of Documents and Records, Control of Nonconforming Material, Incoming Inspection, Corrective Preventive Actions, and Internal Auditing. All procedures are based on API Q1 and best practices.

Deliverables

Deliverables for this project include revised purchasing specifications, revised quality manual, and a final report.

Benefits

Operators bear regulatory responsibility for installed piping quality, while manufacturers face less scrutiny leaving a gap that codes alone don't fully close. Controlling the quality of purchased material requires close operator involvement in the manufacturer's systems, accomplished through standardized purchasing specifications with clearly defined requirements for material, testing qualification at the design level, marking and traceability, and quality plans for testing and inspection at commercial production. The enhanced specifications produced through this program will reduce variability in manufacturing processes, improve overall product quality, improve understanding of applicable industry codes and standards, and raise the bar by setting clearly defined expectations.



Technical Concept & Approach

The team will review existing purchasing specifications against current standards and codes, gather operator feedback, review quality audit findings, and update these documents. Feedback from operators will be collected via survey, group and/or individual meetings.

The team will also communicate with operators and identify and assist them in implementing and using these documents within their organization. Group discussions and individual operator meetings as needed will be scheduled and held. Operators will be encouraged to identify and invite their SMEs (procurement and others) to participate to assist with the acceptance and implementation of the enhanced purchasing specifications.

Results/Status

In 2025, GTI Energy Team developed and submitted a survey to sponsors to gather feedback on the use of purchasing specifications and began to review and update purchasing specifications.

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Purging Gas Pipes into Service without Venting Gas to Atmosphere

Researchers are demonstrating a vacuum purging method that eliminates the need to vent natural gas to the atmosphere when purging pipelines into service. This technology helps utilities reduce methane emissions, improve safety near purge points, and reduce the time required for complex purging operations. This project also supports commercialization of this technology.

Project Description

Gas purging occurs on a routine basis in the natural gas industry. Pipelines are purged to prevent the presence of a combustible mixture of gas and air. Failure to follow good purging guidelines and procedures may result in serious incidents and/or outages. A vacuum purging methodology was developed in Phase 1, patented (US Patent 11,821,564) and further enhanced and demonstrated in the field during Phase 2 of the project. Vacuum purging is a purging alternative to avoid methane emissions related to purging pipelines into service. This method can be used to energize new or recommissioned pipelines by means of a vacuum pump, in order to avoid methane emissions into the atmosphere and minimize the risk of gas and air mixture in the energized pipes. The team continues to demonstrate the system to OTD members through live field pilots to gain necessary feedback and ultimate acceptance to bring the vacuum purging method identified in Phase 1 to a state of commercial readiness.

Deliverables

This project will provide the project sponsors with a comprehensive report that describes the vacuum system components and operation. This includes: Equipment that the vacuum system will need to safely and seamlessly operate “off-the-shelf”; Development and integration of a methane monitoring

system to enhance safety while pulling vacuum to commission gas distribution pipe; Field demonstration of the enhanced vacuum system; and a manual that pertains to using the vacuum system for regular day-to-day operations.

Benefits

Minimizing or eliminating the current practice of venting natural gas to the atmosphere during purging can help reduce methane emissions and avoid the social impact of venting gas in an urban area and creating a public nuisance and potentially hazardous environment. By bringing the vacuum purge technology to a state of commercial offering, gas operators will be equipped with a new technology that can help reduce natural gas emissions and benefit from various programs (e.g. PIPES Act 2020, certain states have cap and trade regulations that require continued reduction in their amount of methane emissions per year.)

Technical Concept & Approach

Specific tasks in this project include:

Component Enhancement

The team will acquire and test all components needed so that a gas distribution company can seamlessly and safely operate the vacuum system.

Perform Field Demonstration

Once the field-ready version of the vacuum system has been configured, the team will work with project sponsors to conduct live demonstrations at utility sponsored sites. These demonstrations aim to refine any operational and component issues as well as introduce the technology to the project stakeholders.

Develop user instructions

The project team, with collaboration and input from technology component developers and sponsor feedback, will provide a user’s manual for the system’s safe operation and use.



Connection Kit between Vacuum Pump and Pipe



The vacuum purge system was attached to the new section of steel pipe - attached to the purge stack - and a vacuum was created in the new pipe down to approximately 14.5 psig

Results

In 2024, the project team clarified existing procedures for best practices with subject matter experts that provided more notes to the existing procedure and defined the amount of acceptable air to be allowed in a pipeline.

The team demonstrated the vacuum purging system at several field sites with various OTD sponsors across a range of new PE and steel pipe installations, including the first ever steel pipe purging operation — approximately 3.5 miles of 4-in steel pipe. These operations were successful with almost no natural gas vented to the atmosphere, proving the effectiveness of the vacuum purging system as an alternative to traditional purging operations.

During 2025, the project team and sponsors conducted several additional successful field demonstrations with the vacuum purging system at six member company locations, with some hosting multiple trials. Demonstrations covered a wide range of installations including PE, HDPE, and MDPE pipe ranging from 2-in to 8-in in diameter, with pipe lengths from approximately 300 feet to over 8,300 feet. These field trials validated the vacuum purging method across varied conditions and helped transfer awareness of the technology to member companies' engineering, operations, and other personnel.

In one trial on 8,305 feet of mixed 4-in and 2-in MDPE pipe with three purge risers, the vacuum system achieved -14.17 psi in approximately 29 minutes. After a 15-minute vacuum hold for tightness validation, the system was pressurized to 56 psig in approximately 9 minutes, with purge stacks reaching 96–97% gas concentration within seconds to approximately one minute. The total vac-

uum purge from start to finish took approximately 53 minutes with very little gas vented to the atmosphere. In another trial, the first vacuum purging operation using Supraflow fittings was successfully demonstrated on 2,100 feet of 8-in HDPE pipeline; the entire process took less than 90 minutes, compared to an estimated four hours for a traditional purge.

The demonstrations also revealed several benefits of vacuum purging beyond emissions reduction. At one site, an open service riser valve was discovered during the vacuum operation, demonstrating the system's value as a secondary tightness check before introducing pressurized natural gas. In another case, the vacuum process eliminated the need for additional excavation and squeeze operations that traditional purging would have required for sectionalizing. Operators also noted increased safety by avoiding hazardous, combustible environments near purge points; reduced customer odor complaints; and reduced time to purge complex pipe installations with multiple purge ends, loops, and pre-installed services.

Status

The team continued to engage a potential commercialization partner to finalize a license agreement for the vacuum purging technology. The team continued to support the commercialization process, including conducting field demonstrations to fulfill agreement requirements and promote the system to member companies. Additional field demonstrations are planned for early 2026.

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Identify and Validate Best Practices for Applying Heat to Steel Near PE Materials

The objective of this project was to develop and validate best-practices guidelines for operations that apply heat, such as welding, to steel components located near polyethylene (PE) piping, with the goal of preventing overheating and thermal damage to adjacent PE system components.

Project Description

Currently, there is no industry guidance addressing how heat may be safely applied to steel pipes/components upstream of PE piping while minimizing the risk of potentially overheating the PE pipe. This project investigated heat transfer mechanisms associated with steel heating operations (e.g., welding) and their potential impact on adjacent and downstream PE components.

Deliverables

The deliverables for this project included best practice guidelines for applying heat to steel components near PE pipe, supported by modeling and validation testing, and a final report documenting the work and findings.

Benefits

Establishing best practices for applying heat to steel components near PE pipe can help reduce operational risks associated with excessive heating of PE pipe and components, which can lead to short-term creep rupture. These practices are anticipated to be applicable to welding operations performed near PE piping systems, including transition fittings, stopper nipples, gauge tees, and similar components.

Technical Concept & Approach

The project employed a combination of analytical modeling and experimental validation. Key activities included:

Material Testing

Existing material property data for steel and PE were reviewed.

Finite Element Method (FEM) Simulations

Finite element heat transfer simulations were developed using COMSOL Multiphysics® finite element analysis (FEA) software to evaluate temperature evolution and determine conditions under which PE components could potentially overheat.

Validation Testing

Extreme-case scenarios were physically reproduced in laboratory validation tests to evaluate and validate modelling assumptions and simulation results.

Results/Status

Since the project's inception, significant progress was made toward developing and validating best-practice guidelines for applying heat to steel components near PE pipes. Initial efforts focused on understanding field procedures and gathering material properties and process parameters, which supported development of conceptual FEM models.

The project team initially developed a 2D axisymmetric simulation model using a k-epsilon turbulent flow approach with wall functions. This formulation resulted in non-physical temperature discontinuities at the air-pipe wall interface. The model was subsequently updated to a laminar flow formulation, eliminating the need for wall functions; however, calibration to measured temperatures from physical validation tests remained unsuccessful.

Further analysis identified buoyancy effects caused by heating of the air as a critical heat transfer mechanism. To capture these effects, a 3D FEM model incorporating gravity was developed from the 2D axisymmetric model. The 3D model suc-

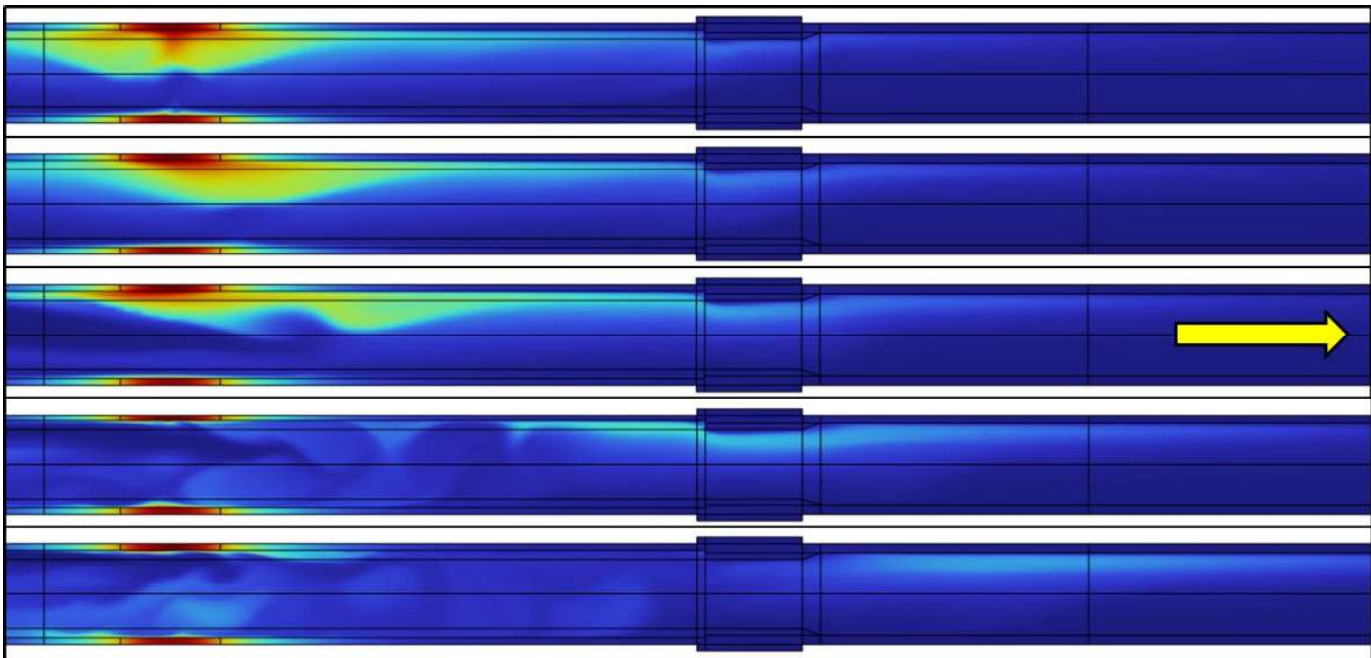


Figure 1: Cross-sectional view of the 3D model mimicking the physical validation tests; showing five sequential time steps from top to bottom; yellow arrow indicated air flow direction. Note: heat is applied on the full circumference of the pipe, but this is not shown here due to the cross-sectional view.

cessfully captured buoyancy-driven air stratification, pooling of hot air at the top of the pipe, and downstream mixing when gas flow was introduced.

The inclusion of gravity introduced simulation challenges during the transition from the no-flow heating phase to the post-heating flow phase. Extensive efforts were made to calibrate the 3D model using data from multiple validation tests; however, alignment with individual thermocouple measurements could not be achieved.

Despite these challenges, the project yielded valuable insights into heat transfer between steel pipe and adjacent PE pipe:

- Gas flow rate following heat input has a major impact on dissipating heated gas and reducing downstream temperatures.
- Cooler incoming gas mixes with heated gas, reducing peak temperatures and shortening the residence time of hot gas in downstream pipe segments.
- Simulations indicate that, under the tested conditions, conduction of heat through steel transition fittings alone is not a significant contributor to PE heating, provided adequate separation distance and reasonable aggregate heat input duration are maintained.

These findings support existing field practices that specify minimum distances between heat application and PE components and the use of wet wraps or forced convection to enhance external cooling. The results also indicate that operating procedures could be enhanced by explicitly addressing allowable heat input duration and post-heating gas flow rate and duration.

The project further demonstrated that calibration of a 3D FEM model to a specific field case is extremely difficult and requires a very high level of fidelity in temperature measurements, heat input characterization, and gas pressure and flow data as a function of time. Because such detailed boundary condition information is generally unavailable in field operations, use of FEM to predict specific field scenarios is of limited practical value and carries significant uncertainty.

This project is complete. A Final Report was issued in March 2025.

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Product and Process Validation Program

Researchers will test selected products against relevant codes and industry standards to validate ongoing manufacturing quality and compare performance across suppliers. This work will provide natural gas utilities with consolidated data to inform supplier decisions and to identify products that may no longer meet design level requirements.

Project Description

The Product Validation Program will provide natural gas utilities with a mechanism to collaboratively validate product performances through testing to confirm that the manufacturers still produce high quality material meeting codes and industry requirements. The program will compare the performances of similar products from various suppliers to help make informed decisions about their usage.

The requirements to validate product performances at the design level are well defined by industry standards. They include testing protocols and methods that products need to be subjected to before introduction to a market or when critical changes to a product design or material occur.

Production processes (equipment, technology, etc.) throughout a product's lifecycle are constantly changing in the commercial manufacturing environment. Product performance is affected by these changes and can be detrimental to its fit and function if not validated. The industry standards, with some exceptions, have no requirements to address these types of changes to confirm that tests performed initially at the design level continue to be valid and that the process continues to be capable of producing products that conform to the requirements given in the relevant codes and standards.

Based on the observations made during the last ten years of quality auditing, the process of ongoing product validation has not been adopted and implemented by most manufacturers due to a lack of industry requirements and increased pressure to improve efficiency and reduce costs. Moreover, during the audits, it was found that some manufacturers lack documented evidence that the required tests have been completed to meet the requirements of codes and industry standards. There is a need for a consolidated program to validate product performances used by operators to ensure that tests performed initially at the design level continue to be valid and the manufacturing processes continue to be capable of producing products that conform to the requirements given in the relevant codes and standards.

The scope of the Product Validation Program is to test selected products using relevant codes and industry standards such as API, ASTM, ASME, and MSS-SP. The program sponsors select the products included in the testing cycle during the scoping task. Sponsors will receive a list of products that have already been tested and their results.

Deliverables

Deliverables for this project include a final report on an individual set of tests by product type and a comparison of product performances, including historical reports.

Benefits

Participation in a product validation program will create efficiencies and cost savings by consolidating the testing of products shared by the sponsors. The program will also assess whether products meet the requirements of industry standards, and provide information to sponsors on product performance to make more informed choices and to evaluate their suppliers.

Technical Concept & Approach

Categories considered for product selection may include criticality, product type, sponsor's infrastructure and working condition, and quality issues. The team will perform sample collection/procurement, sample preparation, and testing. The number of samples to be prepared will be determined based on testing and evaluation needs.

Results/Status

As of January 2026, the testing program is underway across the seven product categories, with the most progress to date on the PE pipes. For the MDPE and HDPE pipe samples, Workmanship and Marking testing and Bend-back testing have been completed. The pipe samples are being conditioned for dimensional analysis in preparation for long term hydrostatic strength (LTHS) and Quick Burst testing, tensile specimens have been prepared for tensile testing, and Thermal Stability specimens have been prepared.

Test rig setup for the service regulator is in progress. Testing of the steel ball valve, the electrofusion tapping tees and branch saddles, and the anodeless meter risers has not yet begun, with those product categories still in the sample preparation and setup stage ahead of testing.

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Commercialization of new version of meter removal tool

The team is working with a manufacturing partner to commercialize a tool designed to loosen seized meter swivel nuts, reducing worker injuries and time spent on meter set rebuilds and leak repairs caused by excessive or unsuccessful wrenching methods.

Project Description

The goal of this project is to commercialize the prototype meter removal tool developed under OTD project 5.21.a, which was designed to loosen corroded and seized meter nuts for meters in capacity classes 250 and 400, connection sizes up to 30LT, for meter swivels with center-to-center (C-C) spreads of 6 and 8.25-in. The commercialization efforts will include field demos of the prototype tool at OTD sponsor sites, any final design refinements, and demonstrations/promotions of the production tool at gas industry events.

Deliverables

Deliverables for this project include a field demonstration at OTD member companies, documented user feedback from the trials; design improvements resulting from the documented feedback from field demo trials; a production tool that is on the market with patent applications filed; and a final report.

Benefits

A tool that can effectively and efficiently loosen seized meter swivel nuts will reduce worker injuries and will save time by reducing the amount of meter set rebuilds and leak repairs caused by excessive or unsuccessful wrenching methods. This tool can also be used by meter shop personnel to save on disassembly time and labor.



JSP Prototype 13 Components



Pivot Bolt for Pivot Arm on GTI Energy Prototype Yoke 2.2 colliding with low clearance meter bar

Technical Concept & Approach

Specific tasks in this project include:

Field Demos

The work in this task includes sending prototype versions of the tool to OTD member companies for field trials and user feedback.

Refine Tool Design

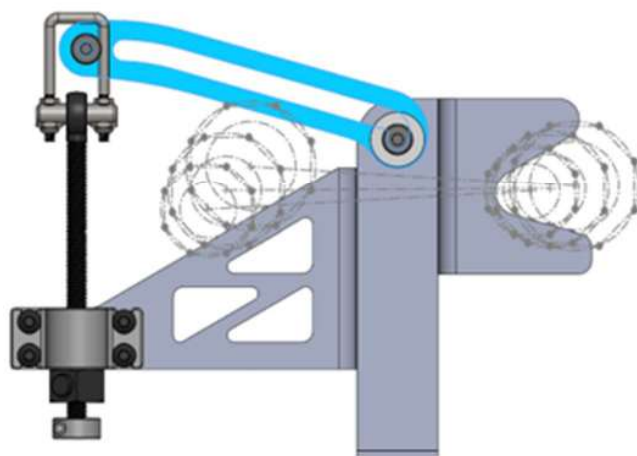
The work in this task includes working with our industrial tool manufacturing partner to refine the prototype design based on user feedback from field demonstrations.

Commercialize Tool

The work in this task includes efforts required to bring this tool to market, including but not limited to working on protecting intellectual property and filing patents, as well as working with the tool manufacturer to conduct promotional and demonstration events at industry conferences and venues.

Results/Status

This phase of the project began in Q4 2024. The team reviewed the latest tool design with project sponsors along with a newer design alternative option to make it easier to use in typical field conditions. Testing showed that the earlier design had practical limitations, so the team shifted focus to a



CAD of Prototype Yoke 2.3

newer alternate design that appeared simpler and more adaptable.

The alternate design, referred to as the “Yoke” design, was easier to install and remove and was more adaptable to a wider range of meter set configurations. Several iterations were developed and tested, and the project team identified the most promising iteration for continued refinement.

Project sponsors preferred the Yoke design because it requires fewer steps, is easier for a technician to handle and operate, and offers greater flexibility for different field conditions. Based on testing and sponsor feedback, the team continued refining the design to fit more common meter set layouts, including locations with limited clearance.

During 2025, GTI Energy and the manufacturing partner continued improving the Yoke design to make the tool easier for field crews to operate. In early 2026, the team expects to meet with OTD sponsors to confirm market need and their desired tool quantities. Following that, the team expects to work with the manufacturing partner to fabricate the latest prototype for sponsor field evaluation.

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Pressure Monitoring and Alert Device for the Replacement of Token Reliefs

The objective of this project was to identify and/or develop a low-cost pressure monitoring device that can be installed in conjunction with relief valves (token or full relief) or monitor regulator.

Project Description

The PIPES Act of 2020 and the associated PHMSA advisory bulletin along with corporate sustainability goals (methane reduction initiatives) are making operators look for options to reduce / eliminate methane emissions from daily operations. This included full and token relief valves. In addition, operators are looking for technologies to notify them of potential events that could lead to over pressurization issues. The project aimed to identify and/or develop a low-cost pressure monitoring device that can be installed in conjunction with relief valves (token or full-relief) or monitor regulator.

Deliverables

Deliverables for this project included analysis of the current usage of pressure relief valves, an updated survey of pressure monitor needs, prototypes of a LoRaWAN enabled pressure monitor, a review of commercially available pressure monitors, test

results for prototypes and commercial devices, and a final report.

Benefits

A monitoring device that could quickly inform operators of pressure anomalies would have multiple benefits. Continuous pressure monitoring can provide operators with awareness of over- or under-pressure conditions, and initial indication data that could allow the operator to prevent the relief from operating. Continuous monitoring and data recording/storage can also enable tracking for trends identification and operations optimization.

Technical Concept & Approach

Specific tasks in this project included:

Survey Utility Requirements

The project team refreshed the AGA SOS questionnaire developed specifically for remote pressure monitor devices. The new version had questions specific to pressure relief valves and questions regarding the cost sensitivity of use cases were included. The results were used to extract a set of requirements and were reviewed to be used in the product identification task.

Build Out LoRaWAN Devices

The team used pressure monitor hardware developed during OTD Project 8.17.a. A few wireless pressure sensors were completely built and tested. The firmware for the monitors was developed and tested. The complete units operate in the 0-87 psig range; changing out the sensing element could extend this to as much as 400 psig.

Review/Procure Commercial Devices

The team surveyed the market for commercial off-the-shelf (COTS) wireless pressure monitors. Manufacturers were contacted for detailed information on their systems. The findings were reviewed with the sponsors to determine pressure monitor systems of particular interest. The identified devices operated across a variety of wireless networks,



Relief Valve Assembly



LoRaWAN-enabled Pressure Sensors Test Setup

including open vs proprietary types.

Pressure Monitor Testing

The commercial pressure monitors of interest were evaluated and graded. A testing program was developed and shared with the project sponsors. The testing included relief valves alongside the pressure monitors. The pressure monitor data was transmitted to a cloud repository for storage. Data was visualized in a dashboard that was accessible by the sponsors.

Results/Status

The project team reviewed and evaluated several commercially available industrial wireless pressure sensing and monitoring devices and identified one particular manufacturer's device as the most robust and reliable device. However the commercially available version utilized a proprietary radio communication network. GTI Energy worked with this manufacturer to develop a newer prototype version that replaces the proprietary network with the open LoRaWAN network communication protocol. GTI Energy tested several prototype units in controlled and outdoor settings. The goal was to determine whether these devices could collect pressure readings, send alerts when readings moved outside preset limits, and continue operating reliably in environments similar to those found in gas utility service.

The testing showed that the evaluated wireless pressure monitors can provide useful real-time

information to operators. The devices consistently and reliably transmitted pressure readings, flagged over- and under-pressure conditions, and supported dashboard-style displays that make the information easier to understand. This kind of monitoring could help operators respond before a mechanical relief device needs to vent gas.

Overall, the project found that remote pressure monitoring is a promising way to improve awareness of gas system conditions, support faster response to pressure concerns, and potentially reduce unnecessary gas releases. Additional evaluation may be needed before broad deployment, including review of installation requirements, communication options, long-term reliability, and how alerts would be integrated into day-to-day utility operations.

The test results are detailed in the final report. Overall, the experience with this technology was positive. While the test items in this project used LoRaWAN for communication, other options such as cellular are readily available.

This project is complete. The final report on Pressure Monitoring and Alert Device to Augment Pressure Reliefs was completed and released to OTD members in January 2025.

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Commercialization of Emergency Leak Clamp Tool

The team is working with a tool manufacturer to commercialize an emergency leak clamp tool that will reduce the time gas vents to the atmosphere during third-party damage events, lowering exposure risk to first responders and the public while helping LDCs meet methane emission reduction requirements.

Project Description

The project aims to commercialize the Emergency Leak Clamp prototype tool developed as part of the prior Emergency Leak Sealing Lance project. A prototype tool was developed to temporarily seal leaks from excavation damages in 4-in dia pipe. This project will continue to collaborate with the industry tool manufacturer and distributor to enhance the design of the leak clamp, develop tools for gas pipeline diameters 2-in thru 6-in and ultimately bring it to market for the industry.

Deliverables

Deliverables for this project include:

- A field-tested product produced by an external tool manufacturing partner prepared to commercialize the tool.
- Generation of a commercialization agreement with an external manufacturer and distributor.
- A final report describing the improvements of the design and testing results of the final product.

Benefits

The development and use of an emergency leak clamp tool to secure the uncontrollable release of gas caused by excavation damage will greatly reduce the risk from gas venting to the atmosphere. This will therefore reduce the exposure risk to LDC first responders and the general public. This will provide LDCs another tool to meet the requirements of the PIPES Act of 2020 which requires LDCs to minimize methane emissions. Also, the use of this tool will reduce the chances of gas supply interruption to customers in the immediate area of the damaged section of pipe. Lastly, this leak

clamp tool could become an everyday tool performing routine operations and maintenance tasks (i.e., service tee removals, service cut-offs, etc.) where the gas supply needs to be stopped off safely and temporarily using an approved industry tool.

6" Tool





Technical Concept & Approach

Specific tasks in this project include:

Design Refinement of Tool

The team will work with a tool manufacturing partner to refine the design of the tool based on sponsor feedback such that it is effective, easy to use, and can be easily fabricated.

Fabricate Final Prototype Design

The work in this task will largely be done by the tool manufacturer to fabricate final prototype tools with oversight by the project team to ensure tool requirements are met. Engineering design services for enhancements and tooling for mass production of the tool will be provided by the manufacturer for the opportunity to commercialize the tool.

Lab & Field Testing

The work in this task includes lab testing and OTD member field demo testing of the fabricated emergency leak clamp tool.

Commercialization

The team will work to bring this product to market. This includes, but is not limited to, working on protecting intellectual property and seeking patents, identifying and working with potential distributors, and efforts to secure licensing agreements.

Results/Status

During 2025, GTI Energy worked with their prototyping and manufacturing partner to refine the design of the tool and fabricated prototype Emergency Leak Clamp Tools for 2-in, 4-in, and 6-in pipe sizes.

GTI Energy shipped prototype tools to a project sponsor for field evaluation. In early 2026 GTI Energy expects to receive operator feedback on tool design, construction, and operation as well as suggestions for any improvements. The project team will then review sponsor feedback and plan next steps toward manufacturing and commercialization.

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Remotely Deployed Double Balloon Stopper Design Refinement Phase 2

The team will further develop a remotely deployed internal balloon stopper that can enter a pressurized 2-in plastic pipe from one remote access point and seal both sides of a gas leak. An internal bypass will continue supplying gas downstream, allowing companies to perform fewer excavations and avoid relights for customers.

Project Description

This project will take the knowledge gained from OTD 5.22.n, which developed a double balloon stopper for a 2-in plastic pipe, to develop a single balloon stopper for the 2-in plastic pipe with an internal bypass. The product developed in this phase of the project will be able to enter a 2-in plastic pipe pressurized up to 90 psig, through a vertical access fitting. It will then be able to travel 50 feet to a gas leak and seal both sides of the gas leak while providing gas service downstream.

Deliverables

Deliverables for this project will include multiple prototypes of the balloon stopper design and a final report.

Benefits

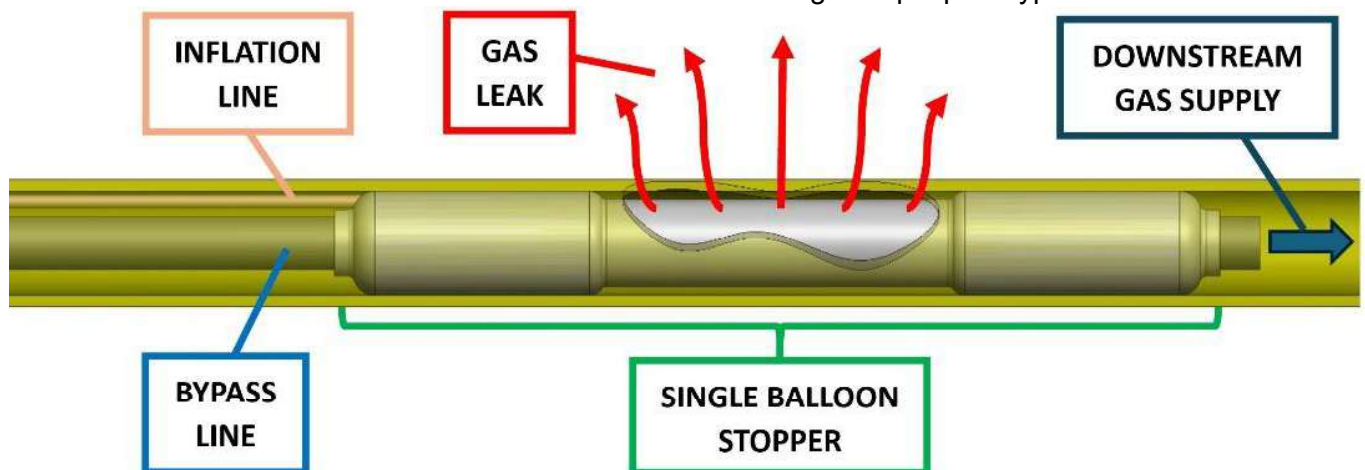
The ability to deploy an inflatable internal stopper from one remote access point to stop a gas leak will allow companies to perform fewer excavations. By having an internal bypass in the stopper, the impact to customers will be reduced by continuing to supply gas downstream. Costs will be reduced by not having to perform relights for customers.

Technical Concept & Approach

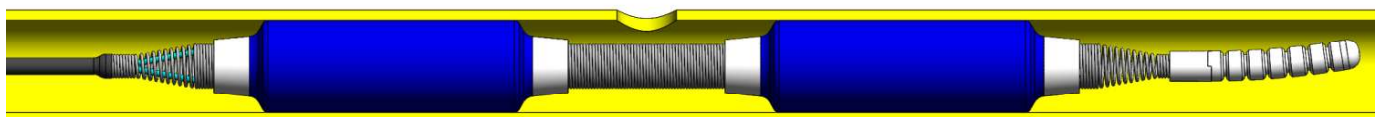
Specific tasks in this project include:

Balloon Stopper Development

The work in this task includes the further development of the design of the single balloon stopper with an internal bypass for a 2-in plastic pipe to improve upon the design developed in OTD 5.22.n. This will consist of designing, fabricating and assembling multiple prototypes.



Proposed 2 IPS Balloon Stopper with an Internal Bypass



Design of Final IBS Prototype from SMP 22702



7-in Version of 2 IPS Balloon Stopper from OTD 5.22.n

Balloon Stopper Testing

The work in this task will include testing the various prototypes. These tests will be conducted on 2-in plastic pipes both unpressurized and pressurized up to 90 psig. Additionally, the testing will consist of deployment of the single balloon stopper through a vertical access fitting with a maximum of a 1.75-in diameter hole.

Results/Status

Initial testing showed that the internal bypass concept can support sealing under pressure, but also identified areas where the design needed further refinement to improve ease of deployment and reliability.

Several bypass configurations were evaluated, but early options did not provide the needed combination of sealing performance and stability. Based on those results, the project team returned to a prior design approach that uses two balloon stoppers connected by a flexible spring assembly.



Large Diameter Springs connected to Manufactured Metallic Connector

The revised design relocated the inflation tubing outside of the connector spring to improve bypass flow. The project team also worked with the bag manufacturer on an improved balloon stopper and developed a new connector to support the updated configuration.

A full series of tests was completed on the revised bypass bladder. Results confirmed that the bladder functions as intended, while also showing that a containment cover is needed to improve stability during operation. Additional testing identified several cover options that showed improved containment and durability.

The most promising cover options are now being further tested to confirm long-term reliability and suitability for the intended application. Next steps include continued validation, refinement of the cover design, and development of recommendations for final material selection.

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Insertion Valve for Gas Mains Phase 2

The team will work with a partner company to adapt insertion valve technology, successful in the water industry, for the natural gas industry, developing a prototype and demonstrating it on a live natural gas system. The adapted technology will give operators a faster, lower cost method for installing the valves needed to isolate sections of their gas systems during emergencies, without interrupting gas service to customers, reducing the risk of gas incidents.

Project Description

This project will work with a partner company to develop their product and perform a field demonstration of a prototype on natural gas. The previous related project 5.23.a (Phase 1) identified this key partner, a company with a successful insertion valve product in the water industry, whose technology can be modified for the natural gas industry. A demonstration of their current water technology was showcased during the 2024 Fall OTD Meeting, providing the groundwork for its adaptation to natural gas.

The team will collaborate with the partner company to adapt their water industry technology for natural gas applications. This will include modifying the technology to meet the specific needs of gas systems, developing a working prototype, and conducting a field demonstration on a live natural gas system to ensure effectiveness and safety. The scope will also include assessing regulatory compliance and engaging with industry stakeholders for feedback.

Deliverables

Deliverables for this project will include a product test plan, testing results and recommendations. Deliverables will also include a field demonstration, video, notes and recommendations. A final report will be issued with an overview of the project results and recommendations. A presentation that summarizes the final report will also be prepared and presented to the sponsors.

Benefits

Gas operators continue to make efforts towards reducing the risk of gas incidents and managing elevated pressure situations. To address these challenges, they need to install more valves to effectively isolate sections of their gas systems during emergencies. Achieving this at a lower cost and faster installation times enables operators to respond more swiftly and efficiently to gas emergencies. The approach reviewed within this project allows valve insertion without interrupting gas service to customers.

Technical Concept & Approach

A discussion with project sponsors will be held to finalize the prototype design and testing plan that includes the steel pipeline diameter sizes and pressures of interest for a product demonstration, and the types of lab testing and field testing. The partner company will create the prototype for natural gas installations and assist with the development of the test plan.

Development of the test plan will include testing to confirm a functional valve can be produced for gas service; following successful functional testing, a gap analysis will be done to determine what (if any) modifications are required to comply with all relevant industry standards as part of the commercialization phase. Detailed scoping of the prototype, design of the prototype, creation of prototype(s) for testing, and delivery of the prototype will also be performed. The team will implement the test plan and conduct a field demonstration of the installation and function of the prototype device at a project sponsor's location.



Results/Status

During 2025, the team initiated Phase 2 of the project and completed project kickoff and scoping activities while advancing early stage device design development. Sponsors were consulted for valve specs and preferences. Throughout the year, the team worked closely with the partner company to review multiple design iterations, focusing on constructability, field assembly, and operational feasibility. Work during the year also included revision of two different drafts of the valve and applicable industry standards.

The team and the partner company worked collaboratively to identify alternative methods to validate valve performance after installation in the field and ensure compliance with safety and operational requirements. Acceptance of field-based pressure testing as part of the installation process will be evaluated with project sponsors and reflected in the installation guidelines and procedures as appropriate for each operator.

A key outcome of 2025 was the incorporation of sponsor feedback that led to reclassification of the device from an insertion valve to a stopper. This update helped align the project with the most appropriate standards pathway and industry practices for stopper systems. The partner company supported this direction as a technically sound and practical approach for continued development.

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AGA Purging Manual Revision

This project will ensure that OTD research results on Best Purging Practices for Minimizing Methane Emissions are reviewed and considered for inclusion in the upcoming AGA Purging Manual update. Inclusion of these alternative purging methods will allow for wider adoption and a reduction in the amount of gas released to atmosphere during purging.

Project Description

The AGA Engineering Committee has begun an effort to revise the AGA Blowdown Alternatives white paper and then plans to implement revisions into the AGA Purging Manual. Separate sub-committees are being formed to focus on key areas as they relate to purging alternatives and best practices. One large influence in this effort is the final report written for the joint PHMSA/OTD project 5.23.c Best Purging Practices for Minimizing Methane Emissions that was published in April of 2024.

The team will participate and engage with the AGA Engineering Committee and relevant sub-committees heading this effort to ensure that the alternative methods for purging a pipeline are considered for inclusion in the upcoming AGA Purging Manual update.

Deliverables

The team will provide reports on its work with the AGA Engineering Committee.

Benefits

The purging methods identified in Phase 1 of this work allows operators to purge a pipeline quickly and without venting to the atmosphere. This allows for work to be completed more expeditiously. This project will advocate for these methods to be included as alternative purging methods in an industry accepted practice which will allow for wider adoption and a reduction in the amount of gas released to atmosphere during purging.

Technical Concept & Approach

The team will work with the AGA Engineering Committee as they make additions to the Blowdown Alternatives White Paper and incorporate information about purging alternatives into the AGA Purging Manual. Specifically, the team will ensure that relevant findings from *OTD 5.23.c Best Purging*

Practices for Minimizing Methane Emissions are reviewed and considered for inclusion in the upcoming AGA Purging Manual update. Changes and additions being made to the Purging Manual will be summarized in the form of progress reports for OTD members. The overall aim of these revisions to the AGA Purging Manual is to ensure that operators have a resource to reference when developing their operational procedures for purging alternatives such as cross compression and flaring.

Results/Status

A team member attended the 2025 AGA Fall Operations Meetings as a member of the Engineering Committee and took part in discussions about additions to the AGA Blowdown Emissions Whitepaper to include more operational guidance around the planning and implementation of purging alternatives as identified by more recent purging alternative publications (such as the PHMSA/OTD paper Best Purging Practices for Minimizing Methane Emissions).

The Engineering Committee has developed sub-groups to work on implementing information about new technologies into the AGA Whitepaper, with the intention of potentially bringing this information into the AGA Purging Manual. These sub-groups are also seeking case studies to be used as references in the modified version of the Whitepaper. For example, a case study related to vacuum purging during an OTD project is currently planned to be included, pending approval from project participants.

Revisions and case studies are being finalized and are planned to be submitted to AGA for review before the Spring 2026 meetings.

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Plastic Gas Pipe Damage Assessment Due to High Pressure Water Jets and Cross Bores

Researchers will evaluate the damage caused by high pressure sewer cleaning nozzles on plastic gas pipe cross bores through controlled testing at varying distances. This research will improve natural gas safety by identifying which nozzle styles and operating conditions pose risk to plastic gas pipes, reducing the likelihood of cross bore emergencies and the associated costs.

Project Description

The project team will perform an evaluation of the effect of high-pressure water nozzles from the sewer cleaning industry on PE cross-bores. This will involve working with industry leaders to identify multiple water nozzles used in the sewer industry, constructing a testing rig, and working with industry leaders with the intent to develop a set of guidelines which could be used by the sewer cleaning industry to improve natural gas safety when clearing sewer lines with water nozzles when there is a potential cross-bore.

Deliverables

The deliverable for this project is a final report detailing the project and project results of the high-pressure water nozzle testing.

Benefits

The development of guidelines for operating sewer cleaning nozzles around cross-bores, and testing standards for qualifying these sewer cleaning nozzles, will improve natural gas safety and integrity. It will reduce the risk of potential emergencies and catastrophic incidents and avoid the associated costs. Ruptured cross-bores can create hazardous conditions for homeowners through the unexpected entry of natural gas into a house through the sewer line. This research will help save the cost of repairing damaged homes and has the potential to save lives due to a leaking cross-bore.

Technical Concept & Approach

Specific tasks in this project include:

Review of Standards and Market Research

This task involves reviewing the relevant standards in the sewer industry. The team will identify and procure high-pressure water nozzles for testing and develop a test plan to be approved by the project sponsors.

Development of Test Rig

This task involves designing and constructing a test rig based on the test rig built by the University of Waterloo, adapted to simulate a cross-bore through a sewer line. The vision is that this test rig will be available for future testing as other water jet nozzles become available on the market.

Testing of High-Pressure Water Nozzles

This task involves the testing of multiple high-pressure spinning and straight jet water nozzles on MDPE pipe. The variables tested will be the nozzle style, nozzle brand, and distance from the pipe.

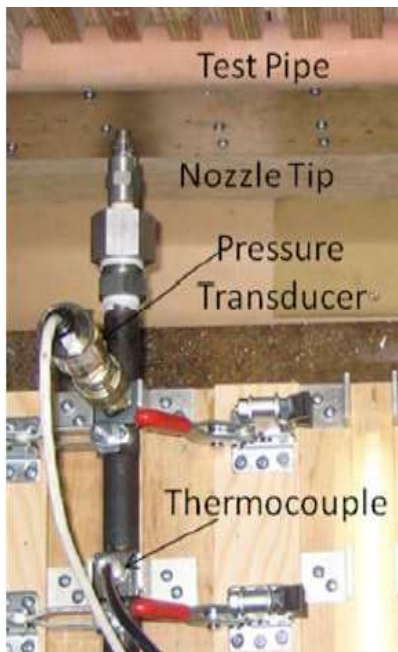
Results/Status

The project team developed a testing rig and subsequently tested six sewer cleaning nozzles from a sewer cleaning nozzle manufacturer to evaluate the damage caused by different style high pressure sewer cleaning nozzles on natural gas cross bores. Of the six nozzles tested, three had forward facing primary jets, which were designed to penetrate through sewer line blockages, while three had rear facing primary jets, which were designed to clear large amounts of debris from the bottom of sewer lines.

These six nozzles were tested for one minute at different distances from different sized MDPE pipe to evaluate the effects of the test distance on the



Blockage caused by Cross-Bore in Sewer Line



Test Rig with Adjustable Pipe Clamps

damage caused by the jets of each sewer cleaning nozzle on the MDPE pipe. The critical test result was defined as the furthest distance with a passing result (Class A or B) or the closest distance with a failing result (Class C, D or F) per the pipe damage classification. The damage classifications are Class A (No Visible Damage SUCCESS), Class B (Surface Polishing

SUCCESS), Class C (Small Puncture of Outer Wall PARTIAL FAIL), Class D (Large Puncture of Outer Wall FAIL), and Class F (Pierced Inner Wall FAIL).

Of the nozzles tested, the only nozzle deemed safe to be used around natural gas cross bores was the rotating head nozzle, since it was the only nozzle that created Class A damage at test distances of 1-in away from the test pipe. The rotating head prevented any of its forward facing and side facing water jets from concentrating on one location of the pipe long enough to sufficiently damage the pipe. The forward facing nozzles created the most damage to the test pipes as they created Class F damage at all test distances, due to their forward facing primary jets which are designed to clear sewer line blockages. Qualitatively, the single forward facing jet nozzle was more damaging than the four jet forward facing nozzle due to its single jet nearly piercing through the opposite pipe wall after 1 minute of testing, while only two of the four jet nozzle's jets pierced through the front pipe wall due to the supplied water pressure being spread between each of its jets.

The rear facing floor style nozzle was the next safest to be used around natural gas cross bores as it provided minimal damage to the pipe. However, since the floor style nozzle still created Class C damage at all test distances, any cross bores that were encountered by the floor style nozzle will need to be visually inspected to determine if the pipe needs to be replaced. The rear facing sewer nozzle also created significant pipe damage (Class

D) at all test distances, where the cross bore is recommended to be replaced as these nozzles create more than 10% wall loss. The rear facing cleaning nozzle had both failing tests (Class D) and partial failing tests (Class C), where the test distance affected the safety of the nozzle.

It was found that the cleaning nozzle became safer when operating at some distance further than 1.75-in away from the test pipe, as that was when the damage became less than 10% of the pipe wall thickness and therefore the results transitioned from failing to partially failing. At 3.75-in and 6.375-in away from the pipe, the cleaning nozzle created small amounts of pipe damage that was less than 10% of the wall thickness and wouldn't necessarily need to be replaced, although further inspection is recommended. At 8-in away from the pipe, the cleaning nozzle created small nicks that were significantly less than 10% of the wall thickness and barely affected the pipe integrity.

From the results of these nozzles, it appears that any nozzle with moving jets would not damage a natural gas cross bore, while any nozzle with static forward facing penetrating jets will damage a natural gas cross bore at any distance. With the rear facing jets there is a wider variety in the damage created, given that one of the three changed damage classifications at different test distances, while the other two had Class C and Class D classifications. There may be a correlation between both an increase in the number of jets and a decrease in the flow of water through the nozzle, and therefore the damage classification of the nozzle. However, it is apparent that each nozzle behaves differently and should be evaluated independently.

The project team recommended proposing a second phase of this project to evaluate additional sewer cleaning nozzles, as well as to vary the test time, nozzle pressure, and flow rates, to determine whether any of these nozzles would be safer to use when operated for shorter periods of time or at lower pressures and flow rates. This additional testing would supplement the work already completed and support development of the guidance document and standard test procedure for the sewer cleaning industry.

This project is complete. A Final Report was issued in May 2025.

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Expanding Hydrogen Storage to Porous Rock Formations

Researchers will evaluate the feasibility of underground hydrogen storage in porous sandstone formations through experimental core flooding and dynamic reservoir simulations. The findings will support development of guidelines to assess site suitability and operational best practices for monitoring and reducing hydrogen loss in porous rock storage.

Project Description

The project aims to develop a framework that helps the industry with identifying suitable underground hydrogen storage sites as well as recommendations for controlling and monitoring H₂ movement and loss within the UHS reservoir. The project will focus on conducting lab experiments and reservoir modeling to develop site screening criteria.

Deliverables

Deliverables of this project include evaluate potential underground H₂ storage, guidelines and recommendations on safety and regulatory issues, and a final report.

Benefits

Develop a set of guidelines to assess the suitability of porous rock UHS sites. Conduct a detailed review of the API underground natural gas storage standards and incorporate them into the framework. Establish operational considerations for preventative or mitigative measures to reduce H₂ gas loss and best practices to monitor H₂ gas loss within the storage boundaries.

Technical Concept & Approach

Specific tasks in this project include:

Characterize Reservoir Performance

Conduct detailed experimental work on caprock sealing and hydrogen dispersion in the reservoir and evaluate possible in-reservoir H₂ losses due to solubility

Run Modeling and Simulation

Fine-tune models with experimental data and run multiple injection scenarios to apply sensitivity analyses and improve long-term reservoir performance estimates over months/years.

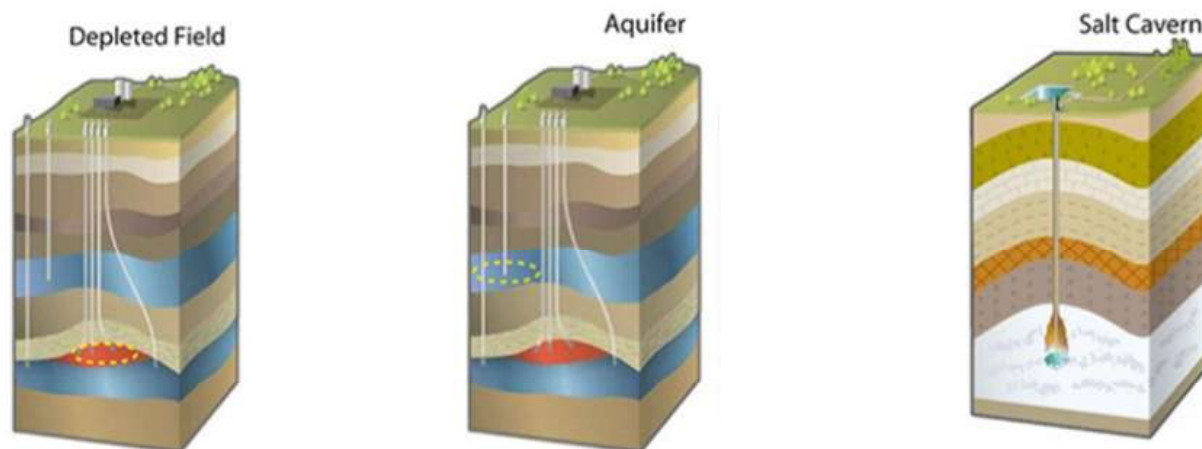
Develop a Framework

Develop a set of guidelines to assess the suitability of porous rock UHS in aquifers. Incorporate the American Petroleum Institute (API) underground natural gas storage standards, operational considerations for preventative or mitigative measures to reduce HS gas loss, and best practices to monitor H₂ gas loss within the storage boundaries.

Results/Status

The Cambrian Ironton/Galesville Sandstone in the Illinois Basin was selected as a representative sandstone/caprock proxy for screening simulations. It is comprised of porous and permeable sandstone intervals interbedded with thin, shale stringers and overlain by a caprock containing clay, quartz, and carbonate cement. A complex geomodel replicating the stratigraphy and petrophysical parameters was constructed for screening assessments. Experimental core flooding approaches were developed to assess direct intrinsic permeability, relative permeability, and hysteresis within both the reservoir and caprock.

The introduction of a specialized experimental setup enabled the assessment of water-hydrogen hydraulic properties under representative in-situ stress and pore pressure conditions. The



Different types of geological structures available for the storage of gases

core flooding device, equipped with anti-corrosive components and a hydrogen leakage alarm system, ensured operational safety at pressures up to 8,000 psi. Single-phase flow tests revealed that the Ironton/Galesville specimen exhibits an intrinsic permeability on the order of 10-17 mD -- significantly lower than typical sandstones due to shale inclusions. This underscores the importance of site-specific characterization in evaluating reservoir suitability for hydrogen storage.

Steady-state two-phase flow tests demonstrated strong hysteresis in relative permeability, particularly for water, likely attributed to heterogeneities and a bimodal pore size distribution within the reservoir. Notably, hysteresis in relative permeability becomes less pronounced after primary drainage and imbibition episodes, suggesting that in field operations, water-hydrogen flow would adhere to secondary relative permeability curves.

Estimations based on capillary pressure curves derived from porosimetry indicated a 10-20% hydrogen loss in the reservoir due to capillary trapping, with potential losses up to 40% in the caprock. While these indirect methods provide valuable preliminary insights, the study emphasizes the necessity of direct measurements for accurate assessment, especially in heterogeneous materials. Since the 40% caprock loss estimate was derived from porosimetry mercury injection pressures that exceed actual subsurface conditions, the percentage of gas stranded in the caprock is likely lower. Simulations incorporating hysteresis in the injection phase followed by daily cycling resulted in a nominal hydrogen saturation of 0.024% in the overlying shale confining unit.

Dynamic simulations incorporating integrated geodata addressed fundamental aspects of subsurface storage, including injectivity, capacity, water production, gas movement, and injection design. Results from this modeling should be considered as initial screening of reservoir performance of hydrogen in a brine-filled aquifer. The results highlight that a horizontal well design with lateral perforations maintains higher gas saturations and reduces co-produced water volumes. The addition of capillary forces retards vertical hydrogen dispersion, with even a relatively thin (12 ft or 3.7 m) shale caprock effectively acting as a vertical barrier over extended injection and withdrawal cycles. Extended simulations up to 180 cycles indicate that vertical hydrogen movement remains constrained, and lateral expansion does not significantly increase, reinforcing the caprock's sealing capacity.

Operational scenarios revealed that the volume of cushion gas directly influences reservoir performance and the potential for hydrogen stranding. Simulations showed that larger cushion gas volumes help maintain reservoir pressure, allowing for continued hydrogen recovery and reinjection over longer periods. Initial hydrogen losses due to hysteresis may decrease over time with continued cycling, suggesting that operational strategies can mitigate early-stage inefficiencies.

This project is complete and a Final Report was issued in December 2025.

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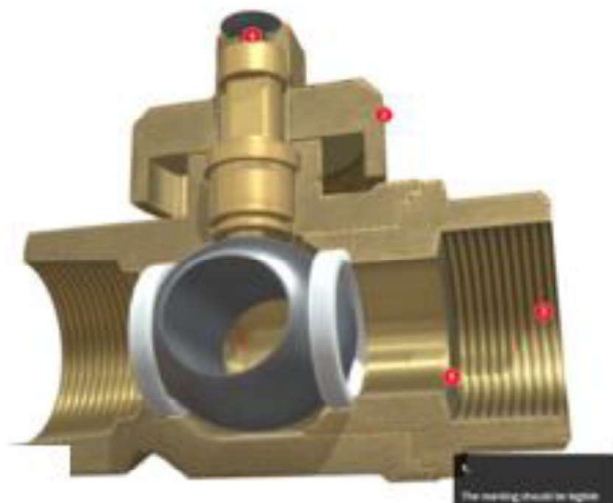


Material Inspection and Testing Training Program

The team will create a standardized training program using micro-videos and interactive 3D models for inspecting and testing purchased materials and components used in gas operators' systems. The program will give utilities consistent, repeatable inspection methods, preserve product knowledge, and reduce risks of operational errors in identifying defective products.

Project Description

To manage risks associated with products that may not meet requirements, utilities implement processes for qualifying materials and routinely inspecting and testing them before they are placed in service. Inspection of purchased materials has become integral to the daily activities of the operators' companies. If implemented effectively, it improves the detection of defective products before they are installed in the system and reduces the risks to safety, reliability, and the public. It is not trivial and can produce different results if performed incorrectly.



Cutaway view of a gas ball valve

Inspection and testing require skill and product knowledge that can be achieved by developing skills-based training programs to help a company's employees perform their duties better and achieve competency and consistency. The project team will partner with manufacturers who have expertise in their products' fit, form, and function to provide input and guidance on the content of this training material.

Deliverables

Deliverables for this project include a list of product types to develop training content for performing material inspections, up to 20 published training modules, quarterly update reports, and a final report summarizing the project deliverables and reviewing the training content with the sponsors.

Benefits

Participation in this program will establish a standardized, comprehensive training content to preserve knowledge and create consistency and repeatability in inspecting and testing of purchased materials, while potentially reducing risks of operational errors in identifying a defective product.



Dresser Style 90 Mechanical Fitting Assembly



Cutaway view of a polyethylene stab fitting

Technical Concept & Approach

The project team will create between 15 to 20 micro-videos supplemented by 3D interactive models in collaboration with subject matter experts and visual content developers. Quizzes will accompany each training module to gauge training effectiveness and comprehension. All developed training content will be accessible using mobile devices, tablets, and office computers. The training content will reside on the GTI Energy platform.

Results/Status

The project team completed twenty 3D interactive models with standard, cut-away, and exploded views and annotations across product categories including anodeless risers, diaphragm meters, excess flow valves, flanges, meter valves, threaded fittings, plastic electrofusion tapping tees and couplings, plastic heat tapping tees, plastic mechanical tapping tees and couplings, plastic pipe, plastic ball valves, rotary meters, service regulators, steel pipe, steel gate valves, steel plug valves, steel weldable fittings, and transition fittings.

Seventeen micro-video training scripts were developed and finalized, and a production trial using the relevant products and measurement tools was successfully conducted in preparation for filming. Filming of micro-videos for seventeen product types was completed at a sponsor's warehouse and the project team's facility.

Editing of all seventeen micro-videos was completed; the team conducted multiple iterations to



Cutaway view of a service regulator

ensure proper synchronization between video content and narration. The finalized versions were reviewed by subject matter experts (SMEs), revised as needed, and uploaded to the training platform.

Quizzes accompanied each micro-video to assess training effectiveness and comprehension.

All 3D models, micro-videos, and quizzes are hosted on a dedicated interactive training website, allowing users to explore the content at their own pace and reinforcing inspection knowledge. Member companies can access the site through an annual licensing agreement, which permits unlimited users within that company to use the content.

The final project deliverables, 3D interactive models and micro videos, were provided to the sponsors as planned in 2025. During the final report review meeting, the sponsors and the GTI Energy team recommended enhancing the existing training materials using the remaining project budget. The proposed improvements include five additional videos and a product specific glossary. Consequently, a revised scope of work was submitted and approved by the sponsors, resulting in an extension of the project's completion date.

This project is complete. A Final Report was issued in December 2025.

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New Product Evaluation Program

The team will create an ongoing program to qualify new products through testing against regulatory and industry standards. The program will give operators qualified alternatives to currently approved materials and components, reducing the individual testing burden on utilities and supporting supply chain resilience.

Project Description

This project creates an ongoing testing program of new products and materials selected collectively by the program sponsors. The new qualified products will provide operators with an alternative to the materials/components that are currently approved and used by operators.

Deliverables

The deliverables for this project include an approved product list that will be created and maintained, and a final report summarizing the test results.

Benefits

Many utilities test new materials before installing them in their systems to ensure quality, regulatory compliance, and safe operation, but performing these tests in-house can be costly and time consuming, and some operators have limited resources. This program will perform that testing collectively, giving operators qualified alternative materials and suppliers without the individual testing burden and supporting supply chain contingencies, bottleneck mitigation, and adaptation to disruptions. The program will complement an ongoing product and process validation effort that tests currently

approved products against industry standards, ensuring that process and product changes have no detrimental effect on their fit, form, and function.

Technical Concept & Approach

For this project, the team will procure, prepare, and test samples. Testing for new products will be based on regulatory requirements.

Results/Status

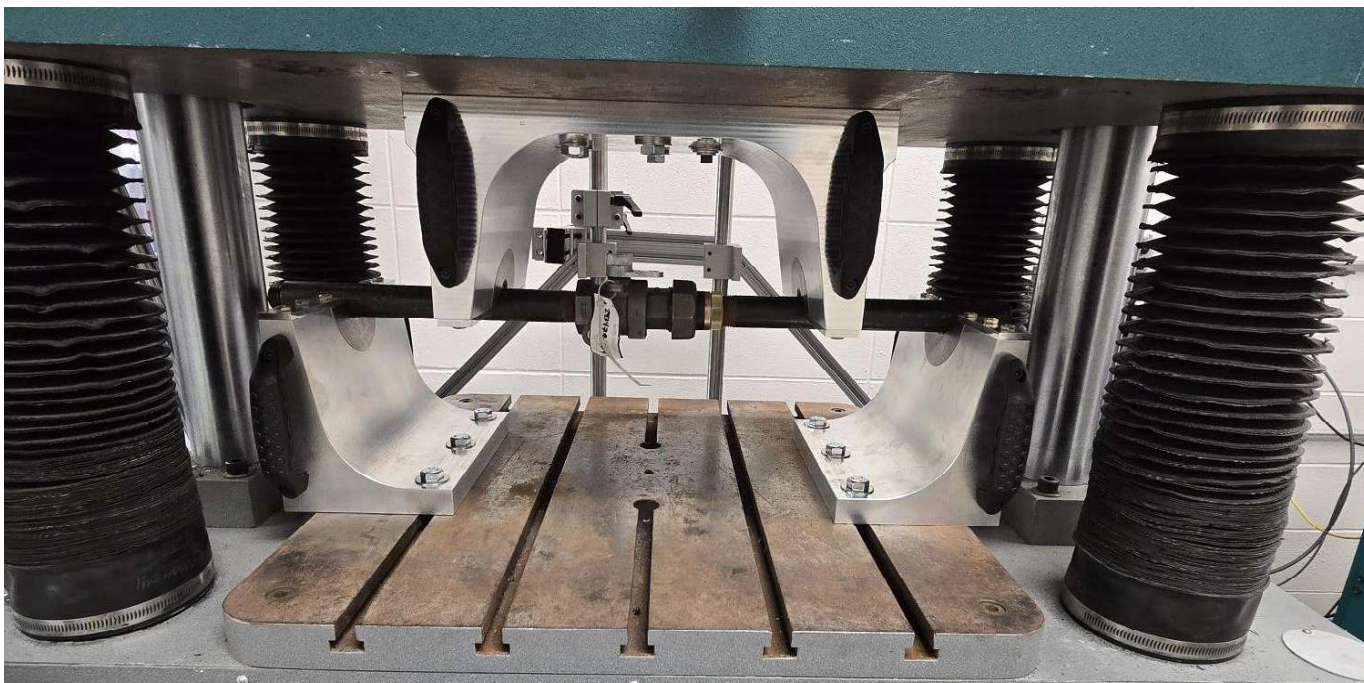
Testing was completed across three product categories under the applicable industry standards. MDPE and HDPE pipes passed all applicable requirements of ASTM D2513-20, including work-



Temperature Resistance Test setup



Meter Valve Twist Test fixture



Bend Test fixture



MDPE Tensile Specimens

manship and marking, dimensions and tolerances, minimum hydrostatic burst pressure, sustained pressure at 73°F, HDB validation, bend back, elongation at break, thermal stability, and squeeze off. During HDB validation at 176°F, one HDPE specimen failed ductilely before reaching the 200 hour target; a replacement specimen was prepared and subsequently passed.

Polyethylene ball valves from both qualified suppliers passed all requirements of ASME B16.40-2008, including the shell test, seat test, operational test, temperature resistance, sustained pressure test (pressure boundary and valve closure), and impact resistance.

Ball meter valves were evaluated against ASME B16.33-2024; valves from one supplier passed all tested requirements (gas tightness, temperature resistance, strength, twist, bending, tensile strength, and turning torque), while valves from a second supplier passed only the strength and twist tests and failed gas tightness, temperature resistance, bending, tensile strength, and turning torque.

Testing confirmed that the qualified PE pipes, ball valves, and one supplier's ball meter valves consistently met performance standards; the second supplier's ball meter valves demonstrated multiple nonconformities, warranting further review before approval or continued use. This project is complete. A Final Report was issued in October 2025.

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Poly-Aluminum Composite (P/AC) Service Line Joining

The team will investigate joining Poly-Aluminum Composite (P/AC) pipe to medium density polyethylene (MDPE) service tubing using electrofusion couplings. A reliable fusion-based joint would give operators a more robust alternative to mechanical fittings for safely connecting vintage P/AC service lines to modern materials during gradual replacement of legacy distribution piping.

Project Description

Poly-Aluminum Composite (P/AC) is a service-line tubing made of PE2306 polyethylene extruded over a copolymer-coated aluminum tube, in use in some distribution systems since 1975. Commercially available electrofusion and mechanical couplings are not designed for P/AC tubing, so connecting P/AC to modern service materials requires understanding the issues posed by its dissimilar construction before engaging manufacturers about purpose-built fittings.

This project will determine whether P/AC tubing can be effectively joined to MDPE tubing using electrofusion couplings. Reliable joining first requires a repeatable method for preparing the fusion surfaces; once a surface preparation method is found, fused assemblies will be prepared using currently accepted joining methods and commercially available fittings.

Deliverables

Deliverables for this project include a list of new materials to test, a sampling plan, test methods, and a final report.



P/AC pipes being joined by a MDPE electrofusion coupling

Benefits

Distribution service piping has changed over the years, from steel, to various types of plastics, and even composite piping materials. Operators are replacing these vintage materials over time. This research will allow operators to safely operate vintage and dissimilar piping systems which are connected to modernized pipelines and ensure connection and joining practices are sound.

Technical Concept & Approach

The primary task in this project is:

Evaluations of Joining Methods

Electrofusion (EF) Joining:

The project team will develop a test matrix which includes the variations in test conditions and measurements to be made to make an initial partial assessment of the integrity of the joint and prepare standard fused assemblies at 73°F, -10°F, and 120°F ± 3.6°F using the fitting manufacturer's joining procedure.

The team will evaluate the fused assemblies by performing elevated temperature sustained pressure tests per ASTM and Fusion Evaluation Tests (FET) per ASTM F1055. If the fusion integrities are deemed unacceptable, the team will prepare additional fused assemblies by modifying the fusion process to impart less energy during the fusion process. This may be achieved by reducing the fusion time manually and evaluate these fused assemblies by performing the tests.

If joining P/AC to P/AC is successful using EF couplings, the project team will then evaluate using EF couplings to join P/AC to MDPE tubing. The team will repeat the above process.

The project team will review the initial evaluation



Specimen 242249-011, Ductile failure in pipe

of EF coupling joining with an OTD member company and may review the results to seek input on the level of interest and viability for a manufacturer to either recognize variations in application of their EF product or develop a new product to meet the identified need. Based on this review, the team will determine the next steps, including whether to proceed with a full battery of ASTM F1055 testing.

Results/Status

The investigation showed that P/AC pipe can be joined to itself using electrofusion couplings when the pipe is properly prepared. Testing showed generally strong fusion quality, although performance was somewhat affected by very cold (-10°F) or hot (120°F) installation conditions.

The project team adjusted the pressure testing approach after early testing showed that the original assumptions did not reflect actual sample performance due to the aluminum layer of the P/AC pipe. Pressure testing was completed based on the performance criteria of ASTM D2513-18 for PE pipe, to understand how the joints performed.

The pressure testing results showed that properly prepared P/AC-to-P/AC joints performed well under expected service conditions. All of the fusion joints met the applicable requirements, and the observed failures occurred in the pipe away from the fusion joint, supporting the overall integrity of the joining

method.

Some test specimens showed small voids within the joint area, particularly when prepared under very low temperature (-10°F). Most of these voids were limited and did not affect the overall joint performance based on the applicable evaluation criteria.

Overall, the results indicate that electrofusion can provide a reliable joining option for P/AC-to-P/AC connections when the pipe surface is properly prepared and the fusion process is controlled. The findings support further consideration of this approach as a practical alternative to mechanical fittings where appropriate.

Testing also provided useful information on the condition of the P/AC pipe material itself. The results indicate that the polyethylene portion of the pipe continues to provide pressure-holding capability consistent with expectations for this type of material (PE2306).

This project is complete. A Final Report was issued in December 2025.

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Evaluate the Effects of Long-Term, Elevated Temperatures on PE Pipe Service Life

Researchers are developing a model to estimate the remaining service life of in-service M8000 and Aldyl-A pipe using accelerated aging tests. Accurate lifetime data will help operators prioritize remediation of aging M8000 and Aldyl-A assets before leaks and emissions occur.

Project Description

The initial phase of the project would perform a literature search and study of long-term heat induced aging of M8000 and Aldyl-A. This would be combined with accelerated aging tests on sponsor-provided M8000 and Aldyl-A pipe samples to develop and validate a model for estimating remaining service life.

Deliverables

Deliverables of this project include a model to accurately estimate the impact of sustained high temperatures on M8000 and Aldyl-A lifetime in various scenarios, recommendations for M8000 and Aldyl-A specimen testing will also be developed, and a final report.

Benefits

Accurate remaining lifetime data will help operators use risk-based data to drive funding and the scheduling of remediation for assets (M8000 and Aldyl-A pipe). Additionally, vintage M8000 and Aldyl-A pipe, which has been identified as a source of emissions, can be remediated before leaks occur.

Technical Concept & Approach

Specific tasks in this project include:

Literature Review

This task will compare the past work done by the project team with more recent developments by others. The team will perform a literature review to capture information relevant to aging infrastructure

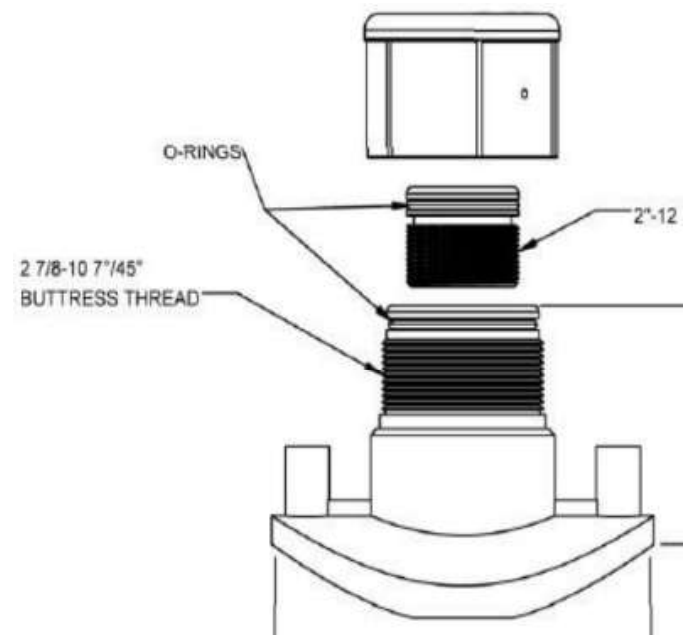
and elevated soil temperatures, establish the data requirements to improve M8000 lifetime estimation, and review the available data and determine what gaps there are that need to be addressed.

Model Testing

This task will obtain ageing data from extensive lab testing and field temperature data. Testing will use sponsor provided pipe samples, data predicted by normal climatic conditions, and data captured by field measurements.

Sample Analysis

This task will process ageing test results from M8000 and Aldyl-A samples provided by the sponsors. The team will summarize the sample test



data in conjunction with metadata for the time and location of sample collection and correlate the measured sample conditions with those predicted by the model.

Results

The project team developed and discussed a test matrix with sponsors. OIT was selected as the methodology for processing both M8000 and Aldyl-A samples, with estimated test duration of up to 4,000 hours. Every ageing sample will be tested via FTIR and OIT test. The test matrix was formulated to provide guidance as to the number of M8000 samples required to establish the ageing behavior of the material. The OIT quantifies the resistance to oxidation of the samples, an indicator of remaining service life. OIT test specimens were extracted from M8000 pipe samples, excluding both the interior and exterior surfaces of the pipe to ensure non-oxidized material is used for the study. The team determined that a minimum of 80 samples per material are required to rigorously establish the remaining life.

The project team identified and tested ovens that can be used for testing, purchased temperature dataloggers, and sample containers to align with the proposed test matrix.

The team conducted a literature review and developed a summary which will be included in future project reports. The summary discusses thermo-oxidative degradation mechanisms in

M8000, the various methods used by researchers to accelerate degradation in a lab environment, the available tools/methods for characterizing the level of degradation in a sample, lifetime model used for thermo-oxidative degradation, and the main challenges encountered by researchers in this field.

Aldyl-A was added to the testing plan. The lifetime prediction model will be calibrated separately for M8000 and Aldyl-A materials.

Status

Preparations for M8000 ageing tests were conducted, with 3 mm discs die-cut from 600-micron slices taken from each of the pipe samples obtained to date. The ageing ovens were tested and calibrated in advance of long-duration testing, and the recently purchased temperature dataloggers were calibrated. Members of the project team were also trained on both FTIR and OIT testing. An initial test round will establish the appropriate sample extraction times, followed by test rounds at different temperatures with the appropriate extraction times. Pipe sample preparation will be performed 0-to-1 days before test rounds are conducted to ensure the thin samples do not age before exposure to temperature.

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Evaluation of Viega MegaPress G Fittings

This project evaluated Viega MegaPress fittings to validate their performance as an alternative to the traditional pipe joining methods used on meter and regulator sets. The fittings can reduce the ergonomic impact on front-line employees and reduce turn-around time for building meter manifolds and restoring customer gas connections.

Project Description

The traditional mechanical joining method for above ground steel piping (e.g., for meter sets) uses threaded or flanged fittings. Assembly and disassembly requires “wrenching” type body mechanics and motions, which can increase the risk of injury for gas pipe technicians/fitters. Viega LLC manufactures a product called MegaPress G fittings, which are crimp style press connect metallic fittings. Plain end steel pipe is “stabbed” into the Viega MegaPress fittings, and a hydraulically powered tool is used to crimp the fittings permanently into place. The use of power tools to join piping instead of manual wrenches can reduce the risk of strain injuries and can increase worker productivity because each joint requires less time to secure.

The Viega MegaPress G fittings are currently rated and approved for use on fuel gas piping, i.e., non-jurisdictional piping downstream of the gas meter. Natural gas operators are interested in finding out if these fittings can be safe alternatives to threaded and flanged fittings, and which possible standards may apply for use on jurisdictional piping upstream of the gas meter.



Deliverables

A list of possible standards that may apply to Viega fittings and their use on CFR 192 jurisdictional piping, and a final report with lab test results.

Benefits

This product can reduce the ergonomic impact on front-line employees and reduce turn-around time for building meter manifolds and restoring customer gas connections.

Technical Concept & Approach

The team investigated applicable ANSI/ASME/ASTM standards for mechanical fittings on CFR 192 jurisdictional steel piping. Pipe test rigs using sample MegaPress mechanical fittings (sizes 3/4-in, 1-in and 2-in dia.) supplied by Viega LLC were designed and fabricated at the project team facilities, and lab test evaluations were conducted including: leak testing, tensile pull-out resistance, corrosion resistance, impact, burst and thermal cycling tests. Comparative testing on 3/4-in and 1-in threaded fittings and 2-in flanged fittings was conducted.



3/4 Viega fittings manifold.



Burst test conducted in a 2-in Viega MegaPress G Manifold.

Results/Status

This project evaluated the performance of press-connect, threaded, and flanged fittings through a series of controlled laboratory tests. The evaluation covered six performance areas: static pressure retention, thermal cycling, burst pressure capacity, tensile pull-out strength, impact resistance, and corrosion resistance under salt-spray exposure. Performance varied by test category, as summarized below.

Pressure Retention and Thermal Cycling

All tested press-connect and flanged fitting samples maintained pressure for 24 hours without observed leakage. Tested threaded fittings showed a few minor leaks, mainly due to apparent variations in thread engagement and sealant application.

All tested flanged fitting samples retained full pressure throughout all temperature cycles. Some of the tested 1-in and 2-in press-connect fittings showed some pressure loss. The tested threaded fittings displayed similar performance inconsistency, indicating that both threaded and press-fit joints were sensitive to thermal expansion and contraction.

Burst Pressure and Impact Resistance

All tested fittings exceeded the required hydrostatic burst pressure threshold. Flanged fittings maintained full pressure integrity after impact. Press-connect fittings retained pressure in most cases, with one seal leak observed in a $\frac{3}{4}$ -in sample. Threaded fittings did not retain pressure after impact due to cracking at the threads.



Tensile test being run and samples that were subjected to the test.

Corrosion Exposure

After 1,000 hours of salt-spray exposure, flanged fittings held pressure in all samples. Press-connect fittings maintained pressure in all small diameter assemblies and in about half of the larger ones. Threaded fittings exhibited mixed results, with leakage in several coated samples. Corrosion effects were dependent on size, coating coverage, and joint geometry.

Status

Additional field testing and longer-term exposure studies are recommended to confirm that the observed performance is consistent in real operating environments, where factors such as installation variability, corrosion, weathering, and dynamic loading can impact long-term reliability. The project team recommended that future testing could focus on the entire meter set assembly made entirely of press-connect fittings. The team also recommended that testing be expanded to different brands of press fittings to compare performance between manufacturers.

This project is complete. A Final Report was issued in November 2025.

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Sensing Water Accumulation in Mains

The objective of this project is to identify sensing technology for water levels in gas mains or siphon drips. The identified sensors will be tested and verified in the laboratory. The sensor testing results and a reference design for a field system will be provided.

Project Description

The project will assess the viability of water level sensing technology suitable for use inside of live gas systems. Drips are intentionally engineered low points installed in natural gas distribution mains to collect condensate and unexpected water infiltration. Drips prevented loss of customer service by providing points where water could collect without blocking the main. Some utilities still have several hundred drips in service; however, water can infiltrate low pressure mains when the water table is high due to weather or water main breaks. A low-cost system is needed that will alert the utility before a critical water level is reached.

A survey of water level sensors will be conducted, and samples procured for bench testing. The current primary candidate is an optical time-of-flight (TOF) sensor that is available off the shelf. The ideal sensor should fit within a ¾-in standpipe and be able to measure the water level from above (sensor facing downward into the main). A mockup of a siphon drip will be constructed or procured. This will be operated at ambient pressure with varying levels of water and the sensor data recorded. If these tests are successful, they will be repeated with compressed air to determine any effects pressure may have on accuracy.

Deliverables

Deliverables for this project include an assessment of level sensing/ranging sensors that are commercially available and a summary report on the technologies reviewed, bench testing of the selected sensors in a simulated siphon drip that allows for reasonable variations in water level and pressure, and data analysis and a summary report of the testing results with an assessment of the viability of the sensors. If the sensor passes testing, a reference design for a field prototype will be produced.

Benefits

Routinely checking and pumping out siphon drips on a regular schedule is time consuming, and if not done frequently, may result in loss of customer service. Having advanced knowledge of the water level and its rate of rise would allow operators to schedule resources and mitigate potential outages before they occur.

Technical Concept & Approach

Specific tasks in this project include:

Sensor Identification

The team will review optical time of flight (TOF) range sensors, electromagnetic “radar” range sensor modules, conduct a general review of range/distance sensors, down-select sensors for bench testing, and provide summary report of sensor identification survey.

Sensor Bench Testing

Work in this task includes designing a test chamber for water level sensor that simulates a siphon drip, providing means to introduce or drain water, providing means to pressurize test chamber, designing a fixture to hold sensor under test relative to chamber, performing a series of sensor tests at atmospheric pressure, and performing a series of sensor tests at 0.25 psig and at 0.50 psig.

Data Analysis

The team will capture data from multiple tests and water levels, create a summary report and graphics from the test data, provide a go/no-go assessment for the sensor technology, and create a reference design for a field deployable system based on the testing results.

Results/Status

The project explored whether non-contact sensors could be used to monitor water levels in gas pipeline siphon drips without placing equipment directly inside the pressurized pipe.

Two sensor types were tested: an infrared optical sensor and a radar sensor. Early testing showed that the radar sensor performed better, so it was selected for additional evaluation.

The team found that narrow siphon drip access pipes can make accurate water-level readings more difficult because the sensor signal can reflect off the siphon drip pipe walls. Several improvement options were identified, including narrowing the sensor beam, placing the sensor closer to the water, or exploring other sensor types.

Additional testing used a steel test apparatus that simulated real pressurized siphon drip pot conditions. The radar sensor was tested with different pipe lengths and with an added lens intended to improve the signal.

Overall, the radar sensor worked consistently in steel pipes up to 12-in long. The added lens strengthened the signal, but it did not significantly change the sensor's ability to detect the water level.

Performance was less reliable in polyethylene pipe, and sensor readings became more complicated when the water reached the inside of the pipe. Even so, the radar sensor showed promise for future use in steel siphon drip monitoring systems.

Future work could include testing longer access pipes and exploring whether radar can measure water levels through the wall of a polyethylene pipe.

This project is complete. A Final Report was issued in August 2025.

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Pressure Vessel Test Setup

Field Pilot of Real-Time Pipeline Threat Detection System (SPADE System)

Researchers are demonstrating a real-time detection technology that monitors cathodic protection current to detect and locate mechanical threats to rectified steel pipelines, enabling operators to respond sooner and with greater locational accuracy.

Project Description

SPADE has developed and patented a technology to detect and alert pipeline operators of mechanical impacts to their rectified steel pipelines, based on monitoring the cathodic protection current. SPADE aims to discriminate impacts by type of aggression, such as mechanical impact, pipeline/casing electrical short, illegal tapping, lightning strike, etc. Steel pipeline rectifier systems are instrumented with a data acquisition module for continuously monitoring the electric currents applied by the CP system. Changes in the rectifier current signal are analyzed directly at the cathodic protection rectifier where SPADE is installed.

SPADE installed and is monitoring six total SPADE units on an operator's transmission system. Included in the scope is reporting and interpreting of the signals, demonstration of Dashboard monitoring software to operator personnel, as well as maintenance of hardware and software.

Deliverables

Deliverables for this project will include installation, maintenance, reporting and training; full documentation including data, results, conclusions, and recommendations; a Webinar with the SPADE company and funders of this project; and a final report.

Benefits

The SPADE technology aims to provide operators with real-time intelligence and awareness of mechanical threats that occur to their rectified steel pipelines. Detectable threats include third party hits and shorted casings. This technology could allow operators to respond to threats sooner and with greater geo-locational accuracy reducing risk.

Technical Concept & Approach

Specific tasks in this project include:

SPADE Installation and testing on an operator's pipelines

SPADE is supplying and installing the system, including required hardware, for detecting mechanical impact on two rectified transmission pipelines. The SPADE industrial unit, to be installed at each site, has the following features: an industrial-rated weatherproof-enclosed computing module for digital signal monitoring and processing, and a cellular GSM modem for data transmission that can also be adapted for satellite communication.

Monitor the System

Monitor the alarm response of the SPADE systems at each site. This task will include monitoring data



Example photos of installed SPADE units



Mechanical impact simulator device

from each SPADE system on an hourly or daily basis as appropriate with the objective of sending a real-time alert within 2-5 seconds when a mechanical damage occurs on an in-service pipeline, development and enhancement of SPADE algorithms to support monitoring data, identification of any false negative or false positive indications, and demonstration of using the SPADE Dashboard monitoring system.

Alarm Response

Report, interpret, and explain to company personnel the alarm responses of the SPADE system at each site. This task will include reporting to company personnel within 24 hours any alarm responses of the SPADE systems, interpreting and explaining to company personnel the data received that led to alarms and, based on the signals received, identify the cause of any alarms..

System Maintenance

Maintain the installed SPADE systems for the duration of this project with regular on-site field inspections and any necessary maintenance and troubleshooting. The maintenance will include algorithm review and updates. Training focused on the knowledge and tools required to manage and maintain the SPADE systems will be provided as needed.

Results/Status

The project was initiated with installation and configuration of nine SPADE units on a utility partner's transmission system, followed by remote monitoring of data streams from the installed units. Intermittent connectivity issues in three units were traced to modem circuitry manufacturing defects; replacement units were deployed in April 2025. Follow-up field visits in May and June generated new calibration data and allowed adjustments to

detection thresholds, event characterization, and algorithm refinement.

Throughout 2025, the system continued field monitoring of installed units with no mechanical incursions detected during routine monitoring. SPADE monitored, analyzed, and labeled signal events detected on the installed devices, communicated significant events to the pipeline operator, and made ongoing improvements to the Dashboard software platform, including the creation of split user types (Technician and Viewer) and the development and delivery of an advanced interface platform.

A mechanical impact simulator was developed and used during field testing to verify propagation range of induced electrical signals along the pipeline, validate detection thresholds, and enable end users to independently generate controlled impulses. Localization accuracy is currently resolved to the span between two rectifiers, with a joint development program planned to advance toward greater precision (e.g. within a mile or so).

In November 2025, SPADE conducted a field visit to the pipeline operator's system to perform calibration measurements and adjustments and to continue localization development using their portable UL/CE-compliant calibrator. A live virtual system demonstration was jointly conducted in the field, attended by pipeline operator personnel as well as representatives from OTD member companies; a simulated mechanical impact live demonstration was setup between two SPADE locations, which the system successfully detected and localized.

Key learnings from the project indicate that baseline characterization of the "normal" electrical environment is essential to interpret alarms under real cathodic protection conditions; signal patterns from non-mechanical sources must be labeled and incorporated into operational workflows to reduce false positives; and localization improvement depends strongly on calibration and cross-device synchronization, with millivolt-level consistency materially improving interpretability. The project demonstrated advancement in SPADE hardware reliability, localization accuracy, software capabilities, and field-testing and calibration methodology.

This project is complete. A Final Report was issued in February 2026.

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Ultrasonic Meter Testing – Landis & Gyr with Honeywell Added

Researchers will evaluate the accuracy, durability, standards compliance, and smart shut-off and communication performance of the Landis & Gyr G480 and Honeywell AC NXU residential ultrasonic gas meters, helping utilities adopt meters that improve safety through automatic gas shut-off and reduce operating costs through remote, real-time meter reading.

Project Description

This project will evaluate the accuracy of the meter metrology, long-term performance, compliance with meter standards, and smart shut-off capabilities of the Landis & Gyr G480 and Honeywell AC NXU 250 ultrasonic residential gas meters. The majority of the tests on the approved test plan will adhere to ANSI B109.6 – Single Path Ultrasonic Meters, however not every test from ANSI B109.6 is included in the test plan. The remaining tests in the test plan are from DIN EN 14236 – Ultrasonic Domestic Gas Meters, OIML R137 – Gas Meters, or are GTI Energy developed tests.

Deliverables

Deliverables for this project will include collected data results and analysis, peer reviews, sponsor reviews, and a final report.

Benefits

Evaluation of the new Landis and Gyr G480 and Honeywell AC NXU 250 ultrasonic residential gas meters will provide objective performance comparison data for LDCs to evaluate against other ultrasonic meters they may be considering. This type of independent evaluation is often required for regulatory approval for use of these types of gas meters. Evaluating the effectiveness and performance of these meters may increase market adoption of ultrasonic meter technology.

Technical Concept & Approach

Specific tasks in this project include:

Metrology Testing

The work in this task includes both short-term and long-term metrology testing. The long-term metrology test will be conducted for 6 months on an

outdoor test rig to evaluate these meters under the Summer and Winter weather conditions. Additionally, there will be tests involving the evaluation of the ultrasonic sensors at extreme temperatures, humidity and with impurities.

Smart Meter Testing

The work in this task will include conducting multiple tests on the effectiveness of the shut-off valve and other integrated safety features. These tests will be performed at various pressure and flow rates to evaluate the performance of the shut-off at these conditions. Additionally, testing will be performed to evaluate the range/performance of the communication of these new meters. Lastly, testing will be performed to validate that these smart devices will shut off when an excess flow or other critical levels are present.

Data Analysis

The work in this task includes analyzing the data obtained during the previous two tasks as well as preparing the data to be included in the draft final and final reports.

Results/Status

GTI Energy evaluated the Landis & Gyr G480 and Honeywell AC NXU residential ultrasonic gas



Outdoor Accelerated Life Test Rig



Humidity Test Rig

meters across a range of metrology, environmental, and smart meter tests drawn from ANSI B109.6, OIML R137, and DIN EN 14236, along with custom procedures. The tests covered metering accuracy and capacity; durability under accelerated life, thermal shock, temperature, humidity, contaminant, and RF/ESD exposure; low battery operation; shut-off valve performance; and remote communications.

Both meter models met the applicable accuracy and durability criteria in every completed test. Accuracy held within allowable limits before and after environmental exposure, RF and ESD exposure caused no measurable degradation, and low battery conditions did not affect performance. Both meters communicated reliably over cellular LTE-m networks except in heavily shielded basements, were tested as ANSI Class-250 and are intrinsically safe (Class I Div 1 Group D) devices, and their remote shut-off valves showed very low leak rates across temperatures.

Metrology and Accuracy Findings

On the Landis & Gyr G480 meters, the six-month Outdoor Accelerated Life Test ran on three meters for roughly 4,190 hours, and all three maintained their accuracy across the full flow range, including at pilot flow. Accuracy also held through RF and ESD exposure, thermal shock, contaminants, low battery conditions, and across cold, room, and hot temperatures, with an average capacity of 352.4 SCFH. On the Honeywell AC NXU 250 meters, initial and pilot flow accuracy met requirements, accuracy held through humidity exposure, and capacity averaged 488.4 SCFH.

Smart Meter and Shut-off Valve Findings

On the Landis & Gyr G480 meters, the shut-off valve withstood the burst test at the maximum test pressure without leaking and closed reliably with

no leakage or meter drift after contaminants were introduced. On the Honeywell AC NXU 250 meters, the shut-off valve passed the leak test at room, hot, and cold temperatures.

Conclusions

In this project, both meter models passed every test performed and demonstrated resistance to external and internal challenges; environmental conditions such as moisture, temperature extremes, and contaminants did not diminish performance, and accuracy remained stable throughout the evaluation. The integrated shut-off valve, while not classified as a dedicated safety device, proved effective at stopping the flow of gas when closed, and the meters communicated reliably over cellular LTE-m networks except in heavily shielded locations. Overall, the results support smart ultrasonic meters as a viable alternative to traditional diaphragm meters for LDCs.

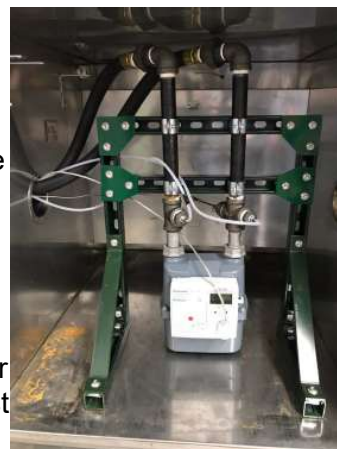
Recommended next steps include compiling testing results from past and future projects into a centralized results dashboard that would allow LDCs to compare meter performance across categories such as accuracy, durability, communication reliability, and shut-off valve features. Further potential work includes expanded sampling, customer specific testing to support procurement and regulatory needs, and validating field connectivity in planned service environments. GTI Energy also has the capability to expand meter testing to encompass the entirety of the ANSI B109.6 standard and to conduct dedicated projects on meter communication capabilities and on the automatic features of the shut-off valve under specific conditions such as high flow or seismic activity.

This project is complete. A Final Report was issued in November 2025.

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Temperature Sensitivity Test Rig

De-blending Demonstration

This project will conduct a feasibility study for installing and demonstrating a de-blending technology in a closed system to evaluate performance and operations under various operating conditions. The data collected would support development of recommended practices for operating and maintaining a de-blending system. This feasibility study will determine the cost and other resources needed to implement a demonstration project.

Project Description

This project will conduct a feasibility study for installing and demonstrating a de-blending system at GTI Energy. The feasibility study will assume a 12-month demonstration to evaluate system performance under various seasonal and operating conditions (e.g., various hydrogen blends, ambient temperatures). It is assumed that system data will be continuously collected.

Deliverables

The planned project deliverables included kick-off meeting presentation, sponsor survey results, rough layout of closed loop demonstration system, list of equipment needed and cost estimates, data collection plan, and a final report containing the findings of the feasibility study.

Benefits

As gas utilities are exploring hydrogen blending into natural gas infrastructure to reduce greenhouse gas emissions, it is critical to address potential impacts on downstream users who may be adversely affected by elevated hydrogen concentrations in their gas supplies. Certain end-users (e.g., CNG filling stations, liquefied natural gas (LNG) peak shaving plants, and steel and glass manufacturers) have strict gas quality requirements and may face significant operational challenges with hydrogen. Example concerns are partial liquefaction, malfunction or degradation of burners, reduced heat transfer, and increased moisture content or emissions. These concerns can compromise equipment and process safety.

Hydrogen separation (deblending) technologies have the potential to protect these sensitive end-users. These technologies can selectively remove hydrogen from a hydrogen-natural gas blend, allowing gas utilities to deliver hydrogen blends to most end-users while still providing near hydrogen-free gas to sensitive end-users with strict gas quality requirements. In addition, deblending technologies can support hydrogen delivery systems for end-use applications such as hydrogen refueling stations or fuel cells. This dual approach has the potential to enhance the flexibility and resiliency of future gas systems.

Technical Concept & Approach

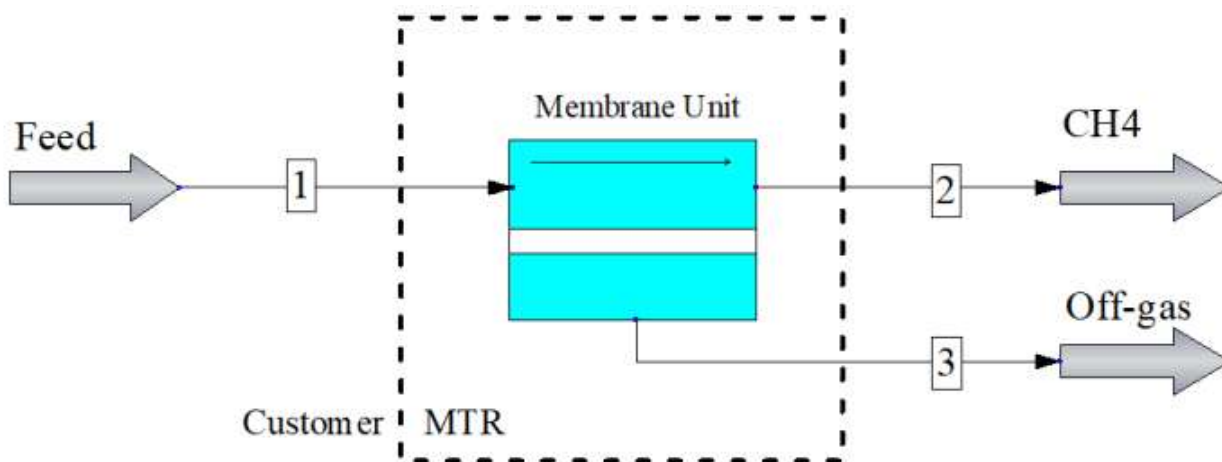
Specific tasks in this project include:

Estimating Resources for Demo Design, Construction, Commissioning, and Evaluation

The work in this task includes collaborating with de-blending technology providers and engineering and construction firms to estimate the costs to design, construct, commission, and evaluate a de-blending technology in a closed loop system at GTI Energy. Anticipated site requirements (e.g., foundation, process connections, assembly and installation of interconnecting piping) will be included in the estimate.

Feasibility Analysis

Once information has been gathered from de-blending technology providers and engineering and construction firms, an assessment on the resource needs and logistics will be conducted to determine if there are any potential issues and risks



Simplified Process Flow Diagram of the De-blending System

with the proposed demonstration project. Analysis findings will inform sponsors before making a go-or-no-go decision for a future demonstration.

Results/Status

This project was a feasibility study to estimate the costs associated with designing, constructing, commissioning, and evaluating a polymer membrane-based hydrogen de-blending system in a closed-loop test system. The assumed end-use scenario was a compressed natural gas (CNG) filling station, with a strict gas quality requirement of 400 to 1,000 ppm hydrogen for sensitive end-users. The project team finalized the specifications and data collection items to be used for designing the test system, which assumed a CNG station usage scenario and a 20% hydrogen-natural gas blend being supplied. The data collection plan included continuous monitoring of power, pressure, flow, temperature, the composition of inlet and outlet streams to determine de-blending efficacy, leakage detection, system downtime, hydrogen losses if any, and heating value measurement of gas streams entering and exiting the de-blending system.

The scope of the feasibility study was revised to focus on a high-level analysis, incorporating initial analysis and cost estimates received and extracting any valuable insights to help operators understand the costs and risks of hydrogen de-blending projects. The project team developed a rough order

of magnitude cost estimate based on initial hydrogen de-blending vendor package quotes; due to the limited data and the early stage of the concept, the estimated costs varied widely. The project team also conducted a high-level risk assessment to identify potential risks, assess their impacts, and outline possible mitigation strategies.

This initial evaluation yielded several key insights for operators planning hydrogen de-blending projects. There is high variability in engineering and de-blending system costs, as they depend on the firm and vendor. Preliminary engineering work is necessary to estimate construction and commissioning costs, as current information is too broad to support firm budgeting. Balance-of-plant equipment and operations and maintenance costs are highly dependent on the specific site conditions and system configurations, making it difficult to generalize costs. Vendor financial stability should be a key criterion in the selection process. The long-term viability of technology providers will directly impact the project's risk profile, as the selected provider will be needed to support project commissioning and ongoing operations.

This project is complete. A Final Report was issued in May 2025.

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SUSTAIN H₂ Storage

Researchers will assess large-scale underground hydrogen storage development across all U.S. regions, evaluating technical factors such as capacity, efficiency, safety, and infrastructure repurposing alongside economic feasibility, to develop an implementation roadmap enabling pilot-scale deployment and supporting utilities in balancing seasonal and regional energy supply and demand.

Project Description

The primary focus of SUSTAIN H₂ is to assess large-scale underground hydrogen storage (UHS) development across all U.S. regions, with an emphasis on future-proofing underground storage facilities to support a range of storage services, including hydrogen storage. The study evaluates key technical factors such as capacity, efficiency, safety, and infrastructure repurposing, alongside economic feasibility and business case. Additionally, SUSTAIN H₂ develops an implementation roadmap that informs immediate next steps, enabling pilot-scale deployment in a safe, reliable, and cost-effective manner.

Deliverables

Deliverables for this project include characterization of suitable geological formations for UHS with assessment of surface infrastructure integration, market-aligned site selection in industrial and power generation sectors, a regulatory and community framework covering compliance and stakeholder engagement, and a field development roadmap outlining technical requirements, TEA/cost projections, timelines, well design and retrofit options, and risk mitigation strategies.

Benefits

As energy demand continues to grow, driven by the expansion of data centers and increasing electrification, there is a need for energy storage solutions to support gas and electric system resiliency from a diverse range of storage methods, including hydrogen, to effectively balance seasonal and regional imbalances in supply and demand. Natural gas storage operators are well-positioned to leverage their existing infrastructure and expertise in safely storing and delivering energy to stabilize demand fluctuations and ensure long-term storage solutions beyond traditional natural gas services. By expediting the path to deployment of underground

hydrogen storage and providing utilities with support to address technical uncertainties, SUSTAIN H₂ paves the way for safe and effective field operations and creates safe field-testing opportunities.

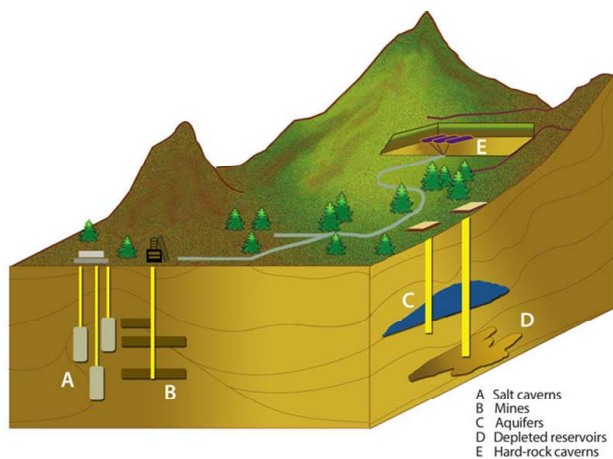
Technical Concept & Approach

SUSTAIN H₂'s research is organized along four technical working streams that provide input into the development of the regional case studies and ultimate field implementation plans.

The first workstream focuses on geoengineering. The team will assess underground storage potential in all U.S. regions by conducting and compiling geological assessments, including mapping, modeling, imaging, and seismic analysis, to populate regional storage databases. Selection criteria for hydrogen storage sites will be developed by performing screening experiments and evaluating reservoirs through literature review, data compilations, modeling, simulation, and testing, with a focus on risk assessment covering microbiology, geomechanics, and geochemistry.

The second workstream covers technology and operations. The team will engage utilities to explore the seamless integration of storage infrastructure with existing transport infrastructure and develop operations and safety frameworks by assessing well design and construction considerations, monitoring and surveillance requirements, and evaluating performance in terms of well integrity and compatibility with hydrogen.

The third workstream addresses market-driven recommendations. The team will analyze economics, markets, and business concepts, focusing on risk management, mitigation, and value-chain integration. Supply-demand analysis for regional and national hydrogen markets will be compiled. Storage capacities needed will be estimated and recommendations provided based on existing capacities and geologies. Techno-economic analyses



Source: PB-KBB, Inc., enhanced by EIA.

and market assessments at regional and national scales will be conducted.

The fourth workstream covers safety and compliance considerations. Policy and regulatory compliance will be evaluated, including licensing, permitting, monitoring, oversight, intervention, decommissioning, and aftercare. UGS operations and maintenance procedures will be reviewed and evaluated, and UHS frameworks will be recommended. The project will facilitate providing peer-reviewed technical briefing materials designed to raise awareness, share insights, and spark dialogue around underground hydrogen storage.

Research findings and field experiences from each workstream will be consolidated into field screening and development workflows. Data and insights will be synthesized into operational considerations for comprehensive field development plans. The team will benchmark promising geological stores for hydrogen and propose potential field pilot locations and designs.

Results/Status

SUSTAIN H₂ was officially publicly launched in September 2024, leading the team to conduct and participate in significant outreach and knowledge sharing events. The SUSTAIN H₂ team headed to Houston for the Gastech Conference, co-hosting the GTI Energy Collaboration Showcase Social and hosted a panel session in collaboration with the Texas Hydrogen Alliance and NeuVentus, with experts from GTI Energy, RMI, FCHEA, and the Clean Hydrogen Future Coalition.

The team also conducted a series of successful webinars including GTI Energy Tech Talk presenting how SUSTAIN H₂ is evaluating the feasibility of UHS, GTI Energy Future Focused Webinar discussing the importance of global collaboration to enable large-scale UHS with experts Serge van

Gessel and Hadi Hajibeygi from IEA Task-42, and State Geological Surveys Webinar engaging with state geological surveys via a special session to evaluate region-specific geology and storage capacities. The team published catalyst blogs on the significance of broad collaboration through IEA's UHS task force and summarizing SUSTAIN H₂'s launch at Gastech. Daniel Weeks from S&P Global Market Intelligence published an article on the newly launched SUSTAIN H₂ project, showcasing GTI Energy's expertise and emphasizing the potential alternatives to cavern storage.

The team facilitated the session on "Hydrogen Transportation and Storage" at West Virginia University's Long Duration Energy Storage Workshop. The team also co-chaired a session at the AGU conference on "Enabling Field-Scale Demonstrations of Underground Hydrogen Storage in Porous Rocks" that explored advancements toward large-scale UHS implementation and economy wide adoption.

SUSTAIN H₂ successfully forged partnerships with 20 organizations, including industry leaders, prominent academic institutions, national labs, and a cohort of collaborators from state geological surveys, enhancing the footprint of the initiative. The team selected the Midwest (aquifer) and South Central (depleted field) as the initial regional case studies, with the East, Pacific, and Mountain regions to follow.

SUSTAIN H₂ has successfully completed development of operations and safety frameworks for hydrogen consistent with natural gas experience; market assessment, analyzing economics, markets, and business concepts, focusing on supply demand analysis for regional and national hydrogen markets; techno-economic analyses and market assessments at regional and national scales, leveraging existing studies; evaluation of policy and regulatory compliance, including licensing, permitting, monitoring, oversight, intervention, decommissioning, and aftercare; experimental assessment (lab testing) of the hydrogen storage depleted field and aquifer; simulation and modeling of the hydrogen storage depleted field and aquifer; and evaluation of microbial, geomechanical, and dispersion risk for solid assessment of expected losses.

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Material Properties Database Related To the Effects of Blasting near PE Pipe

Researchers will enhance blast impact assessment tools by characterizing dynamic material properties of additional polyethylene resins and developing a user-friendly application that will enable system operators to determine safe off set distances for buried assets near blasting activity.

Project Description

This project will enhance the assessment tools developed by GTI Energy that are now being shared with OTD. The enhancements will include the addition of dynamic material properties for three additional polyethylene materials and the development of a user-friendly application for entering blasting parameters, blasting distances, soil properties, asset properties, and other pertinent information for determining safe off sets for each asset.

Gas distribution assets are frequently in place before additional infrastructure such as sewer systems are installed. Installing these additional infrastructure components can entail blasting activity in close proximity to the gas distribution system already in place. There is uncertainty in estimating the impact of blast energy on buried assets, and a set of tools that address this uncertainty is needed to support system integrity decision making in affected areas. Prior work developed models to convert blast energies at known offset distances to pipe displacements. Actual blast data were captured together with pipe displacement data, the blast models were calibrated, and FEM analysis was performed to assess the impact of blast induced displacements on different polyethylene assets in the system. A risk model was developed that ranked the potential for damage per asset type. Different polyethylene materials will have different mechanical responses, and the dynamic

mechanical response for each polyethylene type is needed to feed the risk models for a particular distribution system.

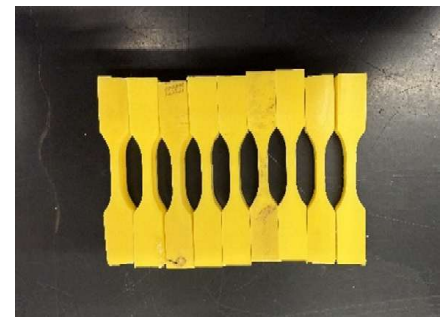
The scope will include mechanical property testing for three polyethylene resins, focusing on dynamic material properties not provided by resin producers, which are needed to assess the impact of blast energy on polyethylene distribution system assets. The assessment tools will be enhanced to provide a user-friendly interface where distribution system parameters and anticipated blast energies will be input. The output will be safe off set distances for assets identified.

Deliverables

Deliverables for this project include mechanical properties of each polyethylene material needed to run response models, a normalized relational SQLite database expandable as new materials are added, and data input forms with structured output data stored in the database.

Benefits

There is uncertainty in estimating the impact of blast energy on buried assets. A set of tools that address this uncertainty will support system integrity decision making in affected areas. The project will enable system operators to define safe blast offset distances for gas distribution assets ahead of blasting activity, enhancing their advanced planning



Aldyl A Pipe Samples; MDPE Pipe Samples; MDPE Pipe Samples – Dog bones



Tensile Test Specimens

ability to ensure safe blasting activity in close proximity to their system.

Technical Concept & Approach

The scope of this project will include mechanical property testing for three polyethylene resins. The focus will be on dynamic material properties, not provided by resin producers, which are needed to assess the impact of blast energy on polyethylene distribution system assets. Material testing will be performed in the laboratory.

A SQLite database will be developed to organize all the data needed to run the risk models.

The previously developed assessment tools will be enhanced to provide an interface where pertinent distribution system parameters and anticipated blast energies will be input. This will include development of the forms and interfaces to existing models, along with development of data structures for analysis outputs that will be stored in the database.

Results/Status

The project team completed sample preparation for all three resin materials (Aldyl-A, MDPE, and HDPE) and programmed the procedure for cyclic testing. The team received three materials from sponsors and completed sample preparation on the Aldyl-A and MDPE pipes first, followed by preparation of the HDPE pipe. The team also started programming the cyclic test on an MTS tensile test machine and prepared specimens for the High-Speed Low Temperature Test (HSLTT).

In Q4 2025, the team started running tensile tests (1-hour break tensile test at room temperature). Preparatory work was initiated on the material database and assessment tool development. All test specimens and test methods have been prepared, and test execution was initiated in Q4 2025.

Tensile testing was initiated in Q4 2025, and the team will start running cyclic, HSLTT, and DTMA tests on specimens in Q1 2026.

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Effects of hydrogen on Aldyl A squeeze off sealing and post-impingement time to failure

Researchers will perform laboratory testing on squeezed and control Aldyl-A samples to investigate hydrogen impacts on long term creep and aging, and whether time to failure differs from natural gas service. The resulting data will help operators determine whether revisions to remediation intervals for squeezed Aldyl-A pipe are necessary after hydrogen is introduced.

Project Description

Researchers will investigate hydrogen impacts on squeezed Aldyl-A pipes, specifically aging and long term creep, and whether time to failure differs from natural gas service. Based on project findings, the project will seek to determine whether existing remediation schedules need to be adjusted to account for the impacts of hydrogen, ensuring safe and reliable operation when hydrogen is present in the system.

Existing natural gas pipelines may be repurposed to transport hydrogen. Squeeze-offs are commonly conducted in distribution natural gas systems to temporarily stop the flow of gas for maintenance, repair, or emergency situations. As operators are planning to introduce hydrogen into polyethylene (PE) systems, there is a need to understand if remediation intervals for squeezed pipes would need to be adjusted when operating with hydrogen. This project will focus on testing Aldyl-A samples as Aldyl-A is more susceptible to failure than modern PE.

This project will build off of historical data obtained from two other OTD projects (project 2.f. that assessed safe operation and maintenance of Aldyl-A and 5.21.j, which has been testing hydrogen impacts on Aldyl-A and high density PE). This will increase statistical confidence of previous findings.

Deliverables

Deliverables for this project will include a final report documenting the laboratory testing performed on squeezed and control Aldyl-A samples. The report will cover the analysis of all the test results and a risk ranking with hydrogen.

Benefits

If existing Aldyl-A systems are to be repurposed for hydrogen transport, it is essential to assess how hydrogen affects the long term durability and performance of these systems. Project data will help determine the lifespan in which the system remains safe and reliable. Lab testing will provide data to determine if revisions to remediation intervals to squeezed Aldyl-A pipe are necessary after hydrogen is introduced.

The lab testing will build upon datasets from previous OTD projects and enhance the statistical confidence in prior findings. Any risk impact due to hydrogen blending needs to be quantified in order for operators to adjust and budget their operating procedures according to the risk impact. Identifying the effects of hydrogen on Aldyl-A pipes will help in estimating the costs associated with potential repairs, replacements, or upgrades.

Technical Concept & Approach

Laboratory testing will be performed on 54 squeezed off and 54 control Aldyl-A samples in high temperature environments. The focus will be on long term creep and aging and if time to failure differs from natural gas service. A 20% hydrogen blend will be used for long term hydrostatic testing. Both a 20% hydrogen blend and 100% hydrogen will be used for dynamic thermo-mechanical analysis (DTMA) testing.

The project team will collect, inventory, and prepare a total of 108 samples. The need for 108 samples is based on long term hydrostatic (LTHS) testing requirements, with 4 sets: non-squeezed tested with methane, non-squeezed pipe tested with 20% hydrogen blend, squeezed tested with methane, and squeezed pipe tested with 20% hydrogen blend. Each pipe sample should be 3 ft long.

DTMA tests will be performed in situ with 100% methane, 20% hydrogen blend with methane, and 100% hydrogen. These tests obtain the activation energy (temperature dependence) of the material, as well as other mechanical behavior properties that can be compared between the methane and 20% hydrogen blend environments. This comparison will be a complement to the hydrostatic testing and testing already performed with OTD 5.21.j.

LTHS tests will be performed at 3 temperatures and 3 pressures per temperature, and 3 replicates per temperature-pressure combination will be conducted, for a basic set of 27 samples. The tests will target slow crack growth slit failures, and samples will be tested until failure occurs.

The project team will also analyze all the test results and develop risk ranking with hydrogen. This analysis will leverage all of the work performed in OTD 5.21.j on Aldyl-A pipes tested with methane and 20% hydrogen blend.

Results/Status

Kickoff and project scoping were completed, with project scope solidified with input from sponsors. Aldyl-A pipe samples were solicited from the project sponsors, and samples were received from one sponsor, with the possibility of additional samples from a second sponsor. The project team completed compiling the inventory on the samples, which determined the number of pipe specimens that could be used for pressure testing and whether additional pipe samples were needed. The samples received were sufficient for up to 71 of the 72 planned sustained pressure tests. Specific sample selection is in progress. Pipes with excessive damage (gouges, etc.) on the outer diameter will not be tested, and pipes with existing squeeze-offs will be used as squeeze-off samples in their as-is condition.

Technical work is expected to start in Q1 2026. Phased array ultrasonic scanning and DTMA testing are the next scheduled tasks. Design of the in situ chamber for DTMA testing in a hydrogen or hydrogen blend environment is underway, with completion later in 2026.

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White paper on utilizing AMI smart meter data

This project will develop a white paper addressing how operators are using, could use, and are reacting to AMI smart meter data, with the aim of providing industry learnings and aiding in the development of industry guidance around smart meter operations.

Project Description

This project will prepare a white paper to answer industry questions about how operators are using, could use, and/or reacting to different AMI data scenarios. Time permitting, the team will explore if there is interest among operators to establish industry best practices or guidelines around shutting smart meter valves in specific scenarios (e.g. pressure sensing).

There are open questions about how current operators manage and use AMI smart meters and the data they collect. Smart meter devices not only send data to operators, but some devices also have features that can be controlled by operators (e.g. actuate the shutoff feature). There is interest among operators to gather information on how other operators are reacting to different AMI data scenarios and how/when/if they are sending control signals to close valves/stop the flow of gas.

Deliverables

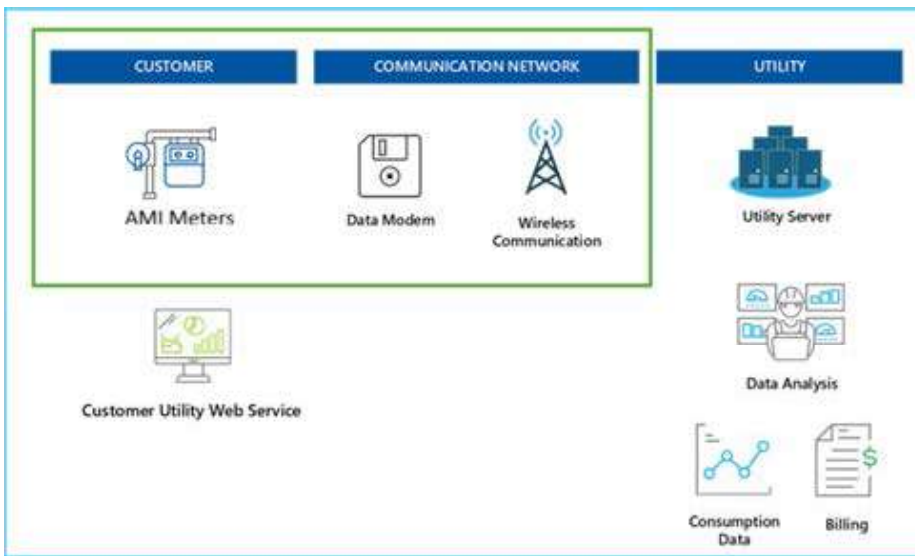
The team will produce a white paper to answer industry questions about how operators are using, could use, and/or reacting to different AMI data scenarios. If time and budget permits, the team will determine if there is interest among operators to establish industry best practices or guidelines around shutting smart meter valves in specific scenarios (e.g. pressure sensing).

Benefits

This project responds to the increased data available to operators as more smart gas meters have been installed into their service territories. There is a general interest in understanding how other operators are making use of this data. This project aims to not only provide industry with learnings of how operators are leveraging AMI data to be proactive in managing risks, but also aide in developing industry guidance.

Technical Concept & Approach

This project will develop a white paper that summarizes how operators are using and reacting to smart meter data with respect to pressure, flow, and temperature values. In support of that effort, the team will gather background research and conduct data gathering meetings. This will include arranging and conducting meetings with SMEs at OTD sponsor companies to gather information on how operators are using (or are considering using) AMI Smart Meter data for operations decisions. The team may also explore teaming up with AGA to help with this research. In compiling the information, the team will also summarize any “best practices” and socialize those with the operator SMEs for review



Components of advanced metering infrastructure

Results

The team conducted a literature review and provided sponsors with a background memo with key findings, including: A technical overview of AMI and common meter types defining key terms and outlining the critical components and system boundary of focus for this project; a comparative analysis of the landscape of smart meter capabilities offered by industry leading vendors and includes details on the meter types, respective benefits and limitations, and performance parameters; an overview of business priorities and considerations for deploying and integrating AMI into business operations; and an overview of regulatory considerations to help inform sponsors on existing guidelines or best practices to consider.

Based on information collected, AMI deployment is still in the early stages for many project sponsors and most are interested in understanding the possibilities of AMI without specific implementation timelines. Across the industry, most utilities have adopted a hybrid deployment strategy that combines installation of new smart meters and retrofitting of existing devices. This approach allows organizations to modernize incrementally while managing capital costs and aligning AMI adoption with the remaining useful life of existing assets.

The study results found that AMI's foundational capabilities are already providing meaningful operational benefits. High-frequency usage data, two-way communication, integrated sensing, and remote operational control collectively support improvements in billing accuracy, customer engagement, anomaly detection, meter health monitoring, and system safety. As utilities gain more experience with these functions, AMI is increasingly viewed as an evolving platform that enables more data-driven decision-making.

A significant area of interest across utilities is the potential for remote shutoff to enhance safety and emergency response. However, actual implementation remains limited. Utilities continue to face regulatory uncertainty, cybersecurity concerns, and the absence of standardized practices aiding in establishing thresholds.

As AMI use expands, utilities are beginning to identify practical challenges with integrating and managing the increased volume and detail of smart meter data. Many existing systems were not designed to support high-frequency AMI data across billing, customer information, and operational functions. The findings also noted added complexity from mixed meter types, different vendor technologies, and the need for stronger cybersecurity, data governance, and analytics capabilities to support effective use of AMI data.

Finally, the study highlights that organizational readiness plays a critical role in successful AMI deployment.

This project is complete and a Final Report was issued in December 2025.

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ERT Functional Testing

Researchers will evaluate the mechanical durability of several encoder receiver transmitter (ERT) models used on gas meters through physical and environmental testing that simulates real world operating conditions. The third party test results will help gas utilities anticipate ERT life expectancy and plan replacement and maintenance activities.

Project Description

The objective of this project is to evaluate the durability and performance of various ERT (encoder receiver transmitter) devices, as requested by the project sponsor and OTD members. ERTs in the field have not lasted as long as expected from a physical wear standpoint. This evaluation is specifically focused on the mechanical durability of the devices as a replacement option for existing ERT devices.

Evaluation of the communication network is not part of the scope; the project's evaluation will instead focus on testing each of the ERTs' ability to withstand harsh environmental conditions and/or physical impacts.

Deliverables

Deliverables for this project include a final report documenting the evaluation of the durability and performance of various ERT devices.

Benefits

The ERT (encoder receiver transmitter) is a device on a gas meter used to collect customer usage data, so an onsite physical meter reading does not need to be obtained. Unforeseen costs and customer dissatisfaction can occur if the ERT were to fail prematurely requiring replacement or onsite repair. Knowing that the ERT is durable and can last the expected life expectancy is crucial for gas operations for planning replacements and maintenance activities.

ERTs in the field have not lasted as long as expected from a physical wear standpoint; therefore, third party testing will assist gas utilities to plan accordingly for the life expectancy. Gas utilities can prevent revenue loss, assist with decision making, and plan for future operational activities, by knowing the time to start with ERT maintenance, ERT replacement schedules, or possible upgrading the technology to smart metering. This approach will evaluate the robustness of the various ERT models provided by the sponsors of this project, providing higher confidence in the reliability of gas metering applications.

Technical Concept & Approach

The project team and the OTD team will work to create a draft test plan to evaluate the durability of the various ERT devices included in this project. The OTD team will provide final approval of the test plan. The project team will then commence testing of the ERT devices according to the approved test plan. This will involve subjecting the devices to physical and environmental testing to simulate real world operating conditions.

The planned tests cover salt spray, temperature shock, UV resistance, humidity resistance, temperature cycle, and drop testing, along with a fire test that exposes the device to an open flame for different periods of time to assess mechanical resistance to flames. Testing continues per sample until the device is no longer operational or it has completed 4 tests.

Results/Status

The project team began drafting a test plan to evaluate the durability and performance of ERT devices. The initial test plan and flow chart were created, and the initial test plan was sent to project sponsors for their approval. Six samples of each of the three ERT device models were received from project sponsors and vendors. A fourth model, an RF residential gas communications module, was added to the testing plan, and the project team received six of those devices.

All units have been received, and connection to the devices is underway. Before testing, the project team is meeting with representatives from each manufacturer to set up communication with the devices. The status of each of the four models is as follows: for one, units have been received and connected, and are ready for testing; for a second, the manufacturer is sending communication equipment needed to connect to devices and begin testing; for a third, the units are having issues connecting to the project team's network; and for the fourth, the team is scheduling a meeting with the manufacturer to connect to the devices. All devices must be able to communicate before physical testing can begin. Since all manufacturers utilize different communications platforms, some have required more coordination with IT departments to allow connection to the devices. Once communication is achieved with all devices, the team will utilize the connection to evaluate device performance throughout the planned physical testing.

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Evaluation of Overpipe

Researchers will evaluate Overpipe protection plates as an additional option for protecting underground gas pipes from dig-ins, traffic loading, and other external loads. This project will help operators understand where Overpipe may fit within existing protection practices for pipes that cannot be buried to minimum cover depths.

Project Description

Researchers will evaluate Overpipe protection plates as an additional protection option for underground gas pipes that may be exposed to dig-ins, traffic loading, and other external loads.

Federal and State codes require operators to implement damage prevention programs. These codes also require minimal burial depth and separation from other underground utilities. Under 49 CFR §192.327, each buried main must be installed with at least 24-in (610 millimeters) of cover. Where an underground structure prevents the installation of a transmission line or main with the minimum cover, the transmission line or main may be installed with less cover if it is provided with additional protection to withstand anticipated external loads.

When pipelines cannot be buried to minimum cover depths, operators may use additional protection to help manage exposure to excavation activity, traffic loading, and related field conditions. These protection methods can include steel plates, concrete caps, or other approved systems depending on the location, operating requirements, and installation conditions.



Overpipe protection plates are being reviewed as another potential option for pipeline protection in applicable settings. The product is marketed to utility operators based on claims related to third-party damage protection, load resistance, reusability, handling, and removability for inspection or repair activities. This project will provide an independent basis for reviewing those claims and understanding practical use considerations.

Deliverables

Deliverables for this project will include documentation of current protection practices, a finalized evaluation plan for Overpipe, testing data and notes, a draft white paper, and a final report.

Benefits

Based on incident data PHMSA has received from pipeline operators, excavation damage continues to be a leading cause of natural gas pipeline failure incidents. Operators continue to implement damage prevention programs and may use additional physical protection, such as steel plates, concrete slabs, or other protective systems, where appropriate for shallow or otherwise exposed assets. Evaluating Overpipe will help determine whether it could provide another practical option for operators to consider within existing damage prevention and protection practices.

This project will evaluate Overpipe protection plates in relation to established protective practices, including steel plates and concrete slabs. The results will help operators understand the conditions where Overpipe may be suitable, the performance considerations that should be reviewed, and how the product may fit within broader pipeline protection approaches.



Simulation of excavation.

Technical Concept & Approach

The project will begin with a kickoff meeting to confirm sponsor objectives, refine the evaluation scope, and identify the key performance questions. The team will review current protection practices and define a practical basis for evaluating Overpipe as an additional option for pipeline protection.

The evaluation will combine engineering review and targeted physical testing to assess how Overpipe performs under conditions relevant to underground gas pipeline protection. Testing materials, assumptions, setup details, and comparison factors will be documented so the findings can be reviewed consistently by project sponsors.

The work may consider excavation-related impacts, repeated surface loading, installation conditions, and environmental exposure. The evaluation will focus on practical questions such as protection performance, pipe response, installation considerations, and limitations under different cover and soil conditions.

The team may also review how Overpipe could be used in common field work settings, including trenches and bellholes. Plate dimensions, handling, and field adaptability will be considered to help determine where the product may be practical and where additional guidance may be needed.

Worker handling and installation considerations will be reviewed at a level appropriate for sponsor decision-making. This may include how plates are moved, placed, removed, and managed in typical field conditions, including whether larger plate sizes introduce equipment or procedural considerations.

The final analysis will summarize test results, operator observations, and implementation considerations in a clear format that supports sponsor review and future decision-making. The intent is to provide usable information on when Overpipe may be an appropriate option, not to position it as a direct replacement for any existing protection method.

Results/Status

During the reporting year, the project team completed planning, site preparation, and testing to evaluate Overpipe protection plates relative to steel protection plates

for excavation damage prevention. An evaluation test plan was developed, and project sponsors provided feedback and recommendations on it. Preparation of the test area included excavating two trenches, installing both the Overpipe and the steel plates, and placing concrete above both protection systems.

Testing was conducted in a pipe farm to simulate field conditions and included simulated excavation using a 22 ton excavator, as well as saw cutting, drilling, coring, and jackhammering evaluations performed through the concrete. All tests were conducted in accordance with the approved test plan, and instrumentation, operator observations, and post-test inspections were used to assess pipe protection performance and operator perception during surface disturbance activities. Pipe response was monitored using triaxial accelerometer measurements, and operator feedback was collected using structured interviews.

Field testing is complete, and data review, interpretation, and preparation of technical documentation were initiated following completion of field testing. Remaining work includes completing the data analysis and technical interpretation, preparing a draft final report for sponsor review, and addressing sponsor comments before issuing the final project report.

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Non Destructible Means to Determine Pipe and Weld Fracture Toughness

Researchers will develop a database of instrumented Charpy toughness measurements from close to 100 pipeline steels conditioned in methane/air and hydrogen, providing the baseline properties needed to evaluate non-destructive methods for estimating pipeline toughness. More accurate prediction of pipeline steel toughness will enhance fitness for service (FFS) assessments and enable repurposing of pipeline networks for hydrogen transport.

Project Description

Several available non-destructive methods for estimating pipeline toughness will be evaluated by comparing their predictions against a database of instrumented Charpy V-notch dynamic toughness measurements from close to 100 pipeline steels. These non-destructive evaluation (NDE) techniques include surface indentation and correlations from inline inspection (ILI) data. Toughness measurements will also be performed on samples conditioned in hydrogen gas.

Performing fitness for service (FFS) calculations for steel pipelines, given a population of internal defects, is based on fracture mechanics approaches that require accurate fracture toughness values for the pipeline material. Obtaining accurate toughness values is nearly impossible without destructive testing, and any destructive testing result is not applicable to other pipeline segments, or welds, other than the one tested. This fact introduces a complication in developing an FFS determination for a pipeline system due to the large variation of fracture toughness across pipeline segments. Variations across segments can result from vintage, manufacturing process, steel chemistry, and even further by welding processes, particularly for girth welds. Further, in the presence of gaseous hydrogen, the toughness of the steels is significantly reduced.

There is a need to develop a database of toughness properties of a wide range of pipeline steels, including in the presence of hydrogen. This project will provide cost share for a broader DOT PHMSA project, "Non-Destructive Means to Determine Pipe and Weld Fracture Toughness." The DOT PHMSA project addresses NDE evaluation of toughness of pipeline steels. This work will provide the baseline materials properties for comparing the various NDE and ILI toughness prediction methods for the DOT PHMSA project.

Deliverables

Deliverables for this project will include correlations between toughness and materials variables. Tables in the database will contain the previously developed steel properties, available meta information for the pipes the specimens were extracted from, and the test data. A final report will also be delivered, available upon publication by PHMSA.

Benefits

Fitness for service (FFS) assessments are critical for safely operating pipeline assets for transport of natural gas and hydrogen. Obtaining accurate toughness estimates from in-service pipes and joints by non-destructive means will enhance assessments of pipeline integrity using FFS methods. This increased prediction accuracy will also enhance pipeline safety through more accurate determination of the state of the pipeline. This will also enable repurposing of pipeline networks for hydrogen transport, a cost effective way of transitioning to hydrogen based fuels.

Technical Concept & Approach

The project will provide cost share for a broader project "Non-Destructive Means to Determine Pipe and Weld Fracture Toughness." This cost share will contribute to the scope of work for instrumented Charpy testing of miniaturized Charpy V-notch samples extracted from a large and diverse set of pipeline steels, and for data analysis and toughness predictions. Instrumented Charpy toughness testing will be performed on each of the steels tested in a prior project, where full chemistry, microstructure, physical properties, and sub sized Charpy toughness was developed.

Tests will be performed at five different temperatures for materials conditioned in methane/air and pure hydrogen environments. Information regarding the upper shelf/lower shelf toughness

and ductile to brittle transition temperature can be determined. Additionally, since the Charpy machine is instrumented, force displacement data will also be obtained from testing.

The results will provide baseline properties for the broader project to comparatively assess the different non-destructive evaluation (NDE) techniques and inline inspection (ILI) methods. The broader project also includes a review of methods in development, or commercially available, for predicting toughness of steels by non-destructive means, and development of a consistent database to include data generated through this project and publicly available data. A materials dataset will be provided to ILI providers for predicting toughness, and their predictions will be subsequently evaluated. Vendors will perform surface indentation on the instrumented Charpy specimens and predict toughness, and the team will evaluate their predictions. Surface indentation will also be performed on pipes assembled in representative ditches at a pipe farm laboratory facility, that are pressurized with methane and hydrogen.

Impact data for samples will be analyzed to develop correlations between the toughness (in methane/air and hydrogen) and material and environmental variables. This data will complement the previously developed dataset of chemistry, microstructure and mechanical properties of steel (collected in the prior project) to include impact toughness and tensile properties in the presence of hydrogen and methane-hydrogen blends. The team will develop an information fusion model for predicting pipeline toughness, and data will also be provided to NDE and ILI providers for refining their toughness predictions.

Results/Status

The project team initially assembled the Technical Advisory Panel (TAP), reviewed literature on available non-destructive methods across over 50 published sources, and engaged multiple inline inspection, indentation, and other non-destructive evaluation providers. Approaches reviewed included destructive testing, minimally invasive (quasi non-destructive) techniques, electromagnetic and acoustic techniques, and toughness prediction models.

Miniaturized Charpy V-notch (mCVN) specimens were machined from a library of pipeline steels. Over 500 instrumented Charpy tests have been performed on specimens from 40 different pipeline steels, tested in air across a range from 155°F to

-45°F to determine the upper shelf energy, lower shelf energy, and transition temperatures. The impact energy versus temperature data is used to estimate the fracture toughness of pipeline steels based on empirical relationships from the literature. Impact testing continues and results are being processed.

Two non-destructive indentation testing providers were engaged. One performed blind surface indentations on 15 mCVN samples and shared results. The other extracted miniature Charpy V-notch samples from 10 pipeline sections, shared results on predictions of dynamic fracture toughness, and performed instrumented indentation and Charpy testing; the material model for predicting fracture toughness using instrumented indentation is in development. Comparative analyses and fracture toughness predictions are being developed from these results.

After conversations with sponsors and TAP members, additional vendors' technologies were also evaluated. Of these, collaboration with a magnetic coercivity measurement provider was initiated, intending to correlate magnetic coercivity measurements with fracture and impact toughness for development of an inline inspection and non-destructive testing tool. Pipeline steel coupons were sent, the measurements were performed, and correlations with magnetic coercivity are being developed. Discussions were also held with two inline inspection vendors and their technologies were reviewed; neither vendor has available technologies for estimating fracture toughness.

Equipment to assess the fracture surfaces and to condition the mCVN specimens at cryogenic temperatures was procured, and setup of the autoclave for high temperature high pressure hydrogen conditioning is complete, with validation testing nearly complete.

Next steps include cryo-testing of materials to determine lower shelf behavior, continued fracture surface analysis and quantification, determination of fracture mechanics based correlations between Charpy impact energy and fracture toughness, hydrogen conditioning and instrumented Charpy testing, detailed planning for in ditch surface indentation, and completion of the Final Charpy Testing Report.

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Inside Methane Detectors Pilots in Operations

The team will pilot, in customer premises, recently developed LTE-M versions of two models of inside methane detectors from two vendors, providing project sponsors with units of each model and onsite training on the detectors and their web based dashboards. The pilot will give operators the field experience needed to improve customer safety through early detection of leaks inside homes and to identify if these technologies enhance their existing monitoring.

Project Description

This project will improve customer safety by piloting recently developed LTE-M versions of inside methane detectors that will be deployed in the field in customer premises. The project will provide operators with training, procedures and needed experience to make operational decisions on this newer technology that has been introduced to the natural gas industry.

As part of this pilot, project sponsors will receive new LTE-M versions of two different detectors to perform field evaluations to help determine how to integrate the technology into operations. Each project sponsor will receive 10 to 15 of each type. These inside methane detectors will be plug and play, ready to go when received, and possess the ability to see alerts or readings on a web based dashboard. The project will provide onsite training of the installation, maintenance and operation of the web based dashboards for the inside methane detectors, and will include monthly meetings with project sponsors to discuss the pilot.

Deliverables

Deliverables for this project will include onsite training of the dashboard and units. A final report will be issued with an overview of the project and recommendations, along with a presentation to the sponsors summarizing the report.

Benefits

Early detection of leaks within a customer's home helps reduce potential incidents. A need exists for learnings to be shared and experiences to be gained by gas system operators in connection with advanced indoor methane detectors and their communications dashboards. This project will assist field and customer services team members in gaining real life experience and knowledge with inside methane detectors that are deployed in the field in customer premises. Gaining a better understanding of new inside detectors allows operators to identify if new technologies enhance their existing monitoring.

Technical Concept & Approach

The team will purchase and distribute both detectors to project sponsors. The work will also include setting up a schedule for onsite training of the web based dashboard and setting up each unit at the project sponsor's location.

Field deployment will occur after the training and will be conducted by project sponsors. The project will also include monthly meetings with project sponsors to discuss the field deployment, address questions, and share learnings.

Results/Status

Over the course of 2025, the project team purchased two models of inside methane detectors from two vendors to be distributed to project sponsors. The team coordinated meetings between the inside methane detector vendors and project sponsors to onboard the sponsors on their systems.

Detectors were shipped to project sponsors across the country, including 10 additional detectors for a sponsor interested in piloting more than the designated amount. on-site and remote demonstrations were underway, and the vendors started training project sponsors on the operation of their methane detectors. By the third quarter, 16 project sponsors were involved in this pilot, with 15 that had received all detectors; out of the 15 with detectors in hand, 12 had completed all training, and training was scheduled for the remaining 3 sponsors.

By year end, all but one project sponsor had received both models of inside methane detectors and training from their respective vendor, and project sponsors had started performing in house testing and field deployment.

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Natural Gas Generators Operational Issues and System Constraints

The team will bring operators together to identify potential system and other issues with natural gas backup generators, discuss the efforts used to identify and locate these generators on their systems, and develop leading practices to resolve the identified issues. These leading practices will support the use of backup generators while minimizing the impact to systems and other rate payers.

Project Description

The team will develop leading practices related to natural gas generators and create an advisory group to discuss issues and possible resolutions. Leading practices may include strategies for identifying customers with backup generators, addressing possible system upgrades, including rates to pay for upgrades, creating installer permitting and notification requirements, special rates and/or interruptible rates, and public awareness outreach materials.

Common in residential, commercial, and industrial settings, natural gas generators are permanently installed and directly supplied with natural gas. There are a growing number of natural gas customers that install gas generators and assume that they will be available to produce power during times of need. However, during recent hurricanes and other large storms, some communities have experienced natural gas outages or low pressure events due to the impact of widespread power outages and the backup generators starting up. Officials with the Louisiana Public Service Commission have expressed concern that older and smaller gas systems may be unable to handle the

burst of demand the increasing number of generators create when the power goes out. The issue is typically related to overloaded gas infrastructure, not the actual supply of gas.

Deliverables

Deliverables for this project will include a database or SharePoint site holding the information collected on methods and practices for the identification of installed or to be installed natural gas backup generators. The project will also produce leading practices and outreach material developed from that information, along with a final report.

Benefits

Emergency standby generators can provide customers with an extra sense of security when power outages occur. However, standby generators with Automatic Transfer Switches (ATS) are creating system gas pressure issues for many operators during electrical outages and other natural disaster type events. Some operators have experienced partial or complete gas system pressure loss during storm related electrical outages. Some operators may also exceed gas nominations, causing pipeline regulators to assess penalties on the



operator. The issue is that operators do not always know where and when these natural gas backup generators are installed, so they can't be planned for.

This project will bring operators together to discuss backup generator system issues and various efforts used to identify/locate them on their system and develop leading practices to support their use while minimizing the impact to systems and other rate payers.

Technical Concept & Approach

An advisory group of subject matter experts will be created to provide industry guidance throughout the project. The team will collect information on methods and practices for the identification of installed or to be installed natural gas backup generators. Information will be gathered from operators, industry associations, contractors, and industry literature.

Alongside this, the advisory group from the various utilities will share issues they are facing and lessons learned. The group will also identify and discuss leading practices to address the potential system issues caused by "unknown" natural gas generators. The information collected will be gathered and organized into a database or SharePoint site.

Additionally, the team and the advisory group will develop a methodology for creating the leading practices and outreach material. They will solicit guidance on methodology and format from the project sponsors. The information collected will then be used to develop the leading practices and outreach material.

Results/Status

An advisory group composed of funding organizations' subject matter experts was formed, background on outages being caused by natural gas generators was reviewed, and high priority issues were identified and discussed. The project team also performed research into details of commercially available natural gas backup generators, service pressure and flow requirements for those generators, and electrical outage data.

Storms and hurricanes causing electrical infrastructure failures remain the primary concern for outages caused by natural gas generators. Utilities continue to struggle to identify the locations where natural gas generators are installed on their system, and, as a result, challenges with modeling have also arisen; many utilities were able to identify installations only through walking surveys. Utilities are also struggling to justify upgrades of natural gas distribution systems to address potential reliability issues caused by natural gas generators during an outage, and need additional guidance to determine how upgrades should be made, both in proactive and retroactive cases.

After discussions with the advisory group, a draft outline for a potential white paper was proposed to the group. The white paper would contain leading practices and would serve as the culmination of knowledge from the group. The white paper would discuss the potential system reliability issues caused by natural gas generators during a power outage and would include leading practices for identification of natural gas generators and modeling. Of special interest to advisory group members was guidance for supporting system upgrades and associated rate approvals, and guidance based on risk or other factors would also be included in the white paper.

Advisory group meetings will continue through 2026 and the remainder of the project, and the project team will focus on development of leading practices, potentially by creation of a white paper, in 2026. Further discussion will take place in 2026 to confirm that the group wants to proceed with white paper development and to establish the contents that will be included.

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Utility Cuts Program GIROW Best Practices and Strategies for Rising Costs and Municipality Fees and Mandates

The team will bring together gas utilities in a consortium to identify and share leading practices for excavation, restoration, and right-of-way initiatives, and to represent the industry's perspectives at the national and state level on municipality fees and mandates related to utility cuts. Addressing these requirements will help reduce overall project costs from excavation and restoration activities while improving the long-term performance of utility cut restorations.

Project Description

This project will identify approaches to manage costs and requirements related to utility cuts and restoration. Right-of-way best practices and other initiatives will be implemented to improve the long-term performance of utility cut restorations while helping ensure that fees, mandates, and paving requirements are appropriately tied to the affected work area and project scope.

Natural gas distribution companies support reasonable restoration specifications and standards, best practices and procedures, and warranty requirements that help ensure the long-term performance of utility cut restorations in public streets. Gas utilities also support efforts to minimize utility cuts in newly renovated or constructed streets by coordinating the planning and construction of utility projects with major public works and municipal improvements, other utility projects, and private developments. To manage costs fairly, restoration and paving requirements should be reasonably related to the location, size, and scope of the utility work area and the quality of the completed restoration. When requirements extend substantially beyond the affected work area, they can increase project costs that may ultimately be borne by customers without directly improving the utility cut restoration itself.



The team will reinstate the Gas Industry Right-of-Way (GIROW) committee, a consortium of gas utility companies, to help ensure that right-of-way policies, fees, and restoration requirements are safe, practical, and appropriately consider the needs of the gas industry, ratepayers, and the municipalities being served. The consortium's purpose is to identify and share excavation and restoration leading practices and right-of-way initiatives, represent industry perspectives at the national and state level, and support a coordinated industry approach. The consortium also works to initiate and support R&D to further enhance excavation and restoration practices, educate the industry on right-of-way initiatives and best practices, and develop working relationships with the American Public Works Association (APWA) and related organizations.

Deliverables

Deliverables for this project will include an organized repository of shared documents for sponsor's use, including newsletters, articles, and guidelines, all in support of the project objective. The repository will be made available via a SharePoint site or other electronic means. An approved final report will also be delivered.

Benefits

Rising costs, fees, and mandates related to excavation and pavement restoration in the public right-of-way are issues facing natural gas distribution companies. Areas with aging utility infrastructure often require increased underground gas, electric, water, and sanitary utility work within public rights-of-way. At the same time, many communities are managing aging road and highway infrastructure and seeking effective ways to maintain roads, parkways, and sidewalks. As municipalities update ordinances and restoration requirements for public right-of-ways, it is important that replacement, paving, and restoration obligations remain reason-

ably related to the location, size, and scope of the utility work area. Requirements that extend beyond the affected work area can increase utility project costs and may ultimately increase costs borne by ratepayers.

Addressing municipality fees and mandates related to utility cuts before they become more prevalent across the country will help reduce overall project costs due to excavation and restoration activities. This is important as gas utilities work to upgrade and maintain aging infrastructure efficiently while helping ensure that restoration requirements are practical, work-area based, and cost-effective for customers.

Technical Concept & Approach

The project team will create and implement a strategy for the gas industry to have a larger impact and clearer internal and external communications on right-of-way issues. The GIROW project will assist utilities in constructively addressing fees, mandates, and restoration requirements with a focus on practical implementation, cost management, and customer impacts.

External communications will include updates on proposed federal rulemaking and coordination of industry response, better overall gas industry communications, evaluation of and response to APWA updates, and publication of news articles supporting the gas industry. Internal communications will include updates to various member committees and sponsors, articles and updates in newsletters, information sharing and updates via a SharePoint site, and gas/electric company surveys on related topics. Technical objectives will include best practices review and evaluation (pavement, restoration, and quality); promotion and support of new technology ideas; and identification of research and study needs.

The work will include the kickoff call and scoping of the GIROW consortium project. Following the meeting, a GIROW project charter document will be developed and reviewed with sponsors. Periodic, suggested quarterly, GIROW meetings will allow the group to identify and discuss street cut requirements, pavement restoration practices, deterioration fees, and related mandates. Subject matter experts from the various utilities will share right-of-way requirements, mandates, and lessons learned. The group will also identify and discuss leading practices to help align these requirements with the affected work area, restoration quality, and customer cost impacts.

Various documents, lessons learned, technical studies, and other relevant information will be gathered and made available via a SharePoint site or other electronic means. In addition, the team will create articles and guideline information to assist utilities in working with local, county, and state agencies to support practical excavation and restoration requirements that are aligned with the work area, restoration quality, and customer cost considerations.

Results/Status

A kickoff meeting was held with project sponsors. Right-of-way issues identified and discussed during past GIROW phases were reviewed, including excavation related topics such as damage reduction, protection plates, soft excavation, and keyhole technology; backfill selection options and leading practices; compaction control equipment selection; and pavement and cut-back sections. Past research initiatives and technology development activities were also reviewed. The project team began collecting, compiling, and organizing GIROW documents for eventual uploading to a centrally located SharePoint location for project sponsors to access.

The team prepared and distributed a survey asking project sponsors to rank the priorities of various GIROW related issues. The top ten priority items span paving requirements and pavement procedures; roadway and worker safety; restoration and degradation fees; notification procedures, permitting, and one-call requirements; damage prevention and excavation practices; and repair and restoration technologies and procedures, including keyhole technology and potholing.

Regular consortium meetings will begin in the first quarter of 2026. The project team and sponsors will review the results of the priorities survey to establish overall priorities for the GIROW consortium meetings, along with some background and other specifics of each of the top priorities identified. The team will also identify actions required to help address some of the higher ranking needs.

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Testing and Validation of the Thermal Effects of External Underground Heat Sources on Plastic Pipe and Fittings

Researchers will experimentally validate theoretical calculations of heat transfer from underground infrastructure such as steam pipes and high-power electrical lines to underground gas pipes and fittings. This research will improve the resilience and protection measures required to develop safer gas infrastructure.

Project Description

Researchers will experimentally validate theoretical calculations of heat transfer from underground infrastructure such as steam pipes and high-power electrical lines to underground gas pipes and fittings. The effects of elevated temperature on plastic pipes are well understood. GTI Energy has created a lifetime prediction model for PE pipes and fittings when exposed to higher temperatures using theory and lab testing. As expected, increased temperatures reduce the hoop stress required to make a PE pipe fail. Based on the temperature effects on PE pipe during this simulated underground testing, a risk profile can be developed for buried plastic gas infrastructure in proximity to nearby external heat sources. This project will also leverage knowledge from prior work and studies conducted by GTI

Standards regarding the separation distance of underground infrastructure focus on protecting gas

pipes from excavation damage caused by work on other utilities but exclude other effects of proximity such as heat. As the NTSB has recently noted, the industry could use additional guidance to improve awareness of the risks posed by thermal damage from nearby heat sources.

Deliverables

Deliverables for this project include a test plan, a heat transfer model, the design of the test setup, the test setup, underground heat transfer testing data, and cleaned data for the report and future research purposes.

Benefits

Damage to underground gas facilities from heat sources poses safety risks to individuals and property. A deeper understanding of the real world impact of heat sources on underground gas facilities will improve the resilience and protection mea-



Steam Pipe External Corrosion, Buckling, and Cracking

asures required to develop safer gas infrastructure. Performing real world testing on the effects of heat sources on plastic pipes will also help inform best practices for operators installing heat-generating infrastructure like steam and high power electric lines in proximity of plastic gas pipes in particular.

Technical Concept & Approach

The team will use a standard heat transfer model to gather theoretical temperature values at different distances from the heat source in different soil types, and build a testing setup to validate those calculations. The test plan will likely include testing different soil types, compaction levels, temperatures of external heat sources, and distances between the heat source and the gas pipe. The team will also create a “baseline” heat transfer calculation model to compare the testing results to, with the model refined as necessary.

The test setup will likely include large containers of different soil types with various sensors to evaluate the heat transfer from the heat source. The heat source will simulate elevated temperatures from underground steam and electrical lines. The containers will have temperature gauges at various distances that track the dissipation of heat from the heat source. Data will be collected using a data acquisition unit that will store temperature and other relevant data along with timestamps.

Results/Status

Over the course of 2025, the team has explored theoretical heat transfer properties of different types of soils commonly found in the United States. Theoretical heat transfer calculations and simulations were conducted to advise the creation of a test plan to validate the effects of underground heat sources near plastic pipes. A test plan was created to validate the results of the theoretical analysis and computer simulations. A test rig design has been conceived to safely validate the theoretical and simulated heat transfer properties in a laboratory experiment.

The test plan references ASME D5334 to track the thermal conductivity of the soil during the test. The procedure involves a sufficiently long needle heat source and a thermocouple to measure the rise in temperature of the soil over a given time. This rate of temperature increase is then related to the thermal conductivity and heat capacity of the soil.

The draft test plan and test rig design are both undergoing a review process. Once the test plan is approved the test rig design will be finalized and all components will be purchased to build the test rig.

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Evaluation of Non-welded Mechanical Joint Restraint Systems for Steel Pipe

Researchers will conduct a market review and evaluate non-welded, bolt-on mechanical joint restraint systems for steel pipe. This would give operators a safe and effective alternative to welded lug systems.

Project Description

There are numerous commonly used non-welded, bolt-on split-clamp type mechanical joint restraint systems available on the market for cast iron and ductile iron pipe sizes. Natural Gas Operators want to investigate if similar options exist for steel systems and evaluate if they would be safe and effective alternatives to traditional welded lug systems. Restraining mechanical joints on steel pipe usually requires a welder to weld lugs onto the steel pipe. Natural Gas Operators are interested in exploring if non-welded options are available to restrain mechanical fittings on steel pipeline systems. The main difference between cast iron pipe and steel pipe in this application is the outer diameter of the pipe.



The scope will include a market review to see what non-welded, bolt-on type mechanical joint restraints are available on the market for steel pipe systems. If available, the team will purchase and test up to three different brands of mechanical joint restraint systems.

Deliverables

Deliverables for this project include a Market Review report, initial testing results and data, and an approved final report.

Benefits

Having an effective and safe non-welded, bolt-on type option for mechanical joint restraints on steel pipe will provide crews more options to safely restrain mechanical fittings without requiring a welder. Having a non-welded option to effectively restrain mechanical joints that are exposed during maintenance operations would be a benefit to operators and would increase efficiency and safety.

Technical Concept & Approach

This project will start with a review of items available on the market which can be tested and fit the purpose and scope of the project. The outcome of this effort will be a Go/No-Go decision made in conjunction with the sponsors on whether to move forward with acquisition and testing.

The team will then acquire/purchase the joint restraint systems that will be tested (up to three different brands) and fabricate and build the testing rigs that will be used in the pipe farm. This will include both hardware, test control instrumentation, and any software and programming. The team will then conduct testing of mechanical joint restraint systems in the pipe farm.

Finally, the team will analyze the collected test data.



Results/Status

The project was initiated and a project kickoff meeting was held with sponsors to define technical needs, target pipe sizes, and overall project scope. During the discussion, sponsors shared their specific needs regarding pipe diameters for potential solutions; among the options considered, sponsors decided 12-in diameter size pipe was the preferred size to test.

Several commercially available clamp-on restraint products from several vendors were researched and reviewed by GTI Energy, but most were ruled out due to incompatibility with steel pipe O.D. sizes. A vendor with a proprietary clamp-on mechanical sleeve sized for steel pipe O.D. was identified for possible evaluation.

GTI Energy is currently coordinating with the vendor to plan for acquiring and testing their clamp-on joint restraining system.

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Plastic Pipe Location Technology Review Gap Analysis Roadmap

Researchers will review prior work and emerging technologies to define the current state of locating buried plastic pipe without tracer wire, and will conduct trials of nuclear density testing as a possible surface detection method. This evaluation will support locating practices intended to reduce damage to underground natural gas infrastructure, repair costs, and safety and property impacts.

Project Description

Researchers will review and evaluate existing methods of locating plastic pipe and compile information from prior OTD efforts and work by others to define the state of the art. Limited field testing may also be performed to evaluate performance. Researchers will consider possible enhancements and potential new technologies that might be applied to detect buried plastic pipe, with nuclear density testing having been identified as a specific candidate of interest.

Some underground facilities cannot be readily located by conventional methods. Plastic pipe without tracer wire can be difficult to locate, tracer wire can break or corrode, and buried warning tape may have a limited service life.

A Nuclear Density Gauge (NDG) is typically used in geotechnical testing to determine if a soil fill meets the required compaction specifications. In concept, detecting a zone of relatively lower density could indicate the location of a plastic pipe filled with gas (low density) surrounded by a mass of soil (high density).

Deliverables

Deliverables for this project include an approved final report. The final report will encompass the results, conclusion and recommendations from the review and evaluation of existing methods of locating plastic pipe and potential new technologies that might be applied to detect buried plastic pipe.

Benefits

Damage to buried natural gas infrastructure can result in safety and property impacts and repair costs. Industry data identifies locating errors and missing locates as leading causes of damage to underground infrastructure, with 40% of under-

ground infrastructure damage affecting natural gas facilities, while 11% are caused by work on natural gas infrastructure. Locating practices and technology help natural gas operators identify and protect infrastructure when work is performed near their facilities.

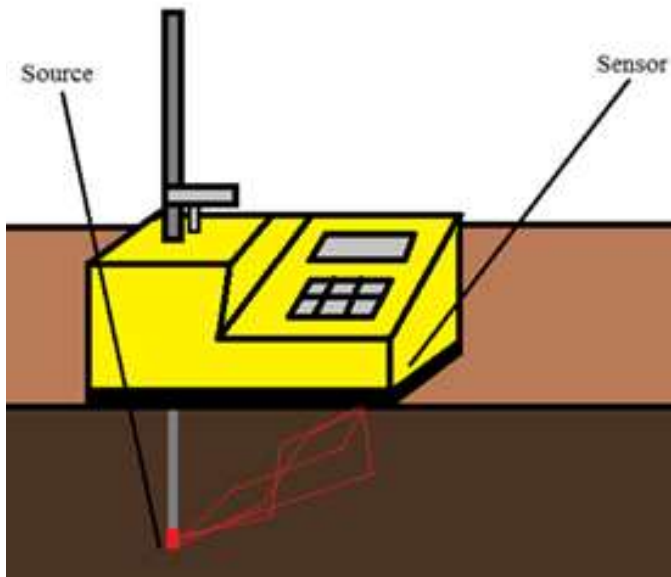
Current methods for locating plastic pipe with no tracer wire or broken tracer wire may require a locating tool to be introduced into a live gas line. Additional methods for locating plastic pipe are being evaluated. Locating practices for plastic pipes without tracer wire may support construction and repair work and help reduce damage associated with locate errors.

Technical Concept & Approach

The team will conduct a review of prior GTI Energy project work related to plastic pipe locating technologies, compile results, and provide updates and recommendations for further investigation. A literature review will be conducted to assess the current state of the art, identify research or products in the market, and assess potential adaptations or enhancements.

The team will also evaluate the use of existing geotechnical testing technology for pipe location. Nuclear density testing with an NDG is commonly used in earthwork construction, a method described in ASTM D6938. A test bed will be constructed of soil with an embedded empty small diameter plastic pipe, and testing will be conducted with the NDG. This exercise could indicate whether density testing in some form could be used to locate buried plastic pipe.

Using the information gathered, the team will analyze available existing or emerging technologies to describe the capabilities and limits of each. The objective of this analysis is to identify gaps and



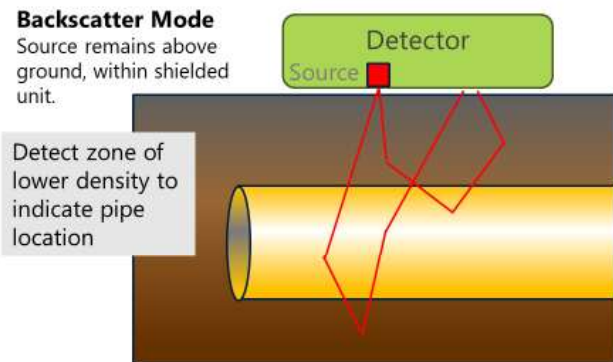
Nuclear Density Gauge Direct Transmission mode

potential next steps for new or updated approaches. This may include field testing of instruments to assess current capabilities and limits. This would occur either at the GTI Energy campus or at an off-site training facility.

Results/Status

The project team has compiled and explored previous OTD projects related to locating plastic pipe without tracer wire. The team has finalized and reviewed literature in its list of previous projects that have evaluated pipe locating technologies. Previously reviewed technologies include AM band Gradiometer; acoustic sensing (AS) devices; EM; multiple ground penetrating radar (GPR) models; insertion tools; and multi function units. Previous projects identified GPR as a technology of interest for locating plastic pipes without tracer wire. Considerations to consider include o equipment cost, data processing, soil moisture, soil content, and asset depth.

A list has been created of emerging technologies that the project team would like to evaluate for this gap analysis, and various mechanical and electrical locating technologies have been identified that have not previously been evaluated. The team has



Nuclear Density Gauge Backscatter mode

interviewed manufacturers and industry subject matter experts and has met with solution providers to discuss available technologies for the project. The project team has met with one vendor in person to receive a demonstration of its sonic locating device and has met with another vendor to discuss its mapping solutions for pipe location. The team will also meet with nuclear gauge manufacturers to see if they have explored other uses for their devices, particularly relating to locating underground objects.

The draft list of technologies the project team plans to evaluate includes a sonic locating device; an all materials locator; Quantum Gravity Gradiometer; and IR Thermography GPR. An industry subject matter expert will review the list and provide input, and a final list will be distributed to project sponsors for review and approval.

The project team has started discussing the test plan that will be distributed to project sponsors for review and approval. Next steps are to meet with the remaining vendors to discuss their solutions for locating plastic pipes, receive a sample unit of the sonic locating device, create a summary of past projects highlighting previously reviewed technologies, and begin development of the test plan.

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Field Demo of Empit CMI Technology

This project will demonstrate Empit's Current Magnetometry Inspection (CMI) technology on two underground transmission mains as an alternative to traditional pipeline integrity assessment methods. If accepted by PHMSA, the CMI technology will provide operators with a new tool to validate the MAOP of transmission lines which is less influenced by pipeline conditions and the environment allowing for more accurate and efficient locates of buried line.

Project Description

Empit will demonstrate their Current Magnetometry Inspection (CMI) technology on two underground transmission mains covering a total distance of 16 miles, over up to 18 days at an OTD Sponsor host site. CMI is marketed as an effective alternative to Inline Inspection (ILI) for unpiggable lines and as an improved alternative to direct current voltage gradient (DCVG) and alternating current voltage gradient (ACVG) surveys. Per CFR 192.632.b.3, operators using Engineering Critical Assessment (ECA) to validate the MAOP of transmission lines may use "other technology" besides ILI, but it must meet certain requirements in order to be accepted by PHMSA.



Deliverables

Deliverables for this project include documented analysis and results from the CMI vendor covering data management and handling, 2D pipeline scan, coating integrity assessment, corrosion assessment, stray current influence on third-party structures, AC interference, and detection and advanced detection of crossing cables, as well as a 6-month Pathfinder app subscription from final report delivery.

Benefits

Common pipeline integrity survey methods such as DCVG and ACVG are limited in their ability to pinpoint indications of an anomaly or to quantify the severity of coating fault, and their performance is also impacted by local conditions such as soil resistivity, current attenuation, and pipeline conditions. A technology which could be less influenced by pipeline conditions and the environment would be of great value to the industry's efforts to more accurately and efficiently locate issues on a buried line.

Technical Concept & Approach

Empit will demonstrate their Current Magnetometry Inspection (CMI) technology, which detects and assesses corrosion issues and pipe wall loss and provides 2D and 3D geo-located mapping scans of the underground pipeline. Following Empit's analysis, the host site may perform validation digs in order to directly assess, observe, and inspect the two lines to provide a comparison of results. The host site also plans to run ILI in the same two lines, after which the results will be compared to the Empit CMI results.



Results/Status

The Empit technical inspection team traveled from Germany to the host site in the US and conducted the on-site CMI inspection. Two transmission line sections totaling about 85,000 feet in length were planned for CMI inspection. Empit successfully performed CMI inspection on about 86% of the total planned length. Minor segments were excluded due to access restrictions from private property, farmland obstacles, and interference from multiple nearby parallel underground structures. Empit has presented preliminary results to the host site and is currently performing data analysis. Once results are received and reviewed, a virtual webinar will be scheduled to present results to all the OTD project sponsors.

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Carbon Management Information Center (CMIC)

The team will develop and maintain analytical tools and technical information for defining decarbonization pathways, enabling stakeholders to document the benefits of direct natural gas, propane, low-carbon, and renewable fuel use as the industry addresses the push toward building electrification and deep decarbonization.

Project Description

The Carbon Management Information Center (CMIC) is a GTI Energy collaborative funded by multiple natural gas industry members as well as the Propane Education and Research Council (PERC). CMIC focuses on reflecting the importance of decarbonization efforts underway throughout the country and demonstrating the vital role that fuels and existing infrastructure will play in accomplishing GHG emission reductions. CMIC will continue to supply technical information and develop tools that will be essential for defining the decarbonization pathways in a carbon-managed future.

CMIC develops publicly accessible tools to document the benefits of direct natural gas, propane, low-carbon and renewable fuel use as the industry addresses external stakeholder voluntary, regulatory, and legislative initiatives. The information is intended to be in the public domain and is formatted to be transferrable by consortium members as they develop and implement other related programs and training materials. The three critical elements of the CMIC mission are: 1) Developing and maintaining modeling tools that demonstrate efficiency gains, reductions in greenhouse gas emissions, and the cost implications of consumer energy choices; 2) Collaborating with external decarbonization modelers to ensure all viable pathways are evaluated; 3) Supporting the development of standards and codes that establish consistent and meaningful metrics for reducing greenhouse gas emissions.

Deliverables

Deliverables for this project include updated CMIC analytical tools, further refinement of the CMIC website intended to serve as a clearinghouse information repository on technical reports, information products, and carbon management activities, and targeted white papers, analytical reports, presentations, and data for stakeholders.

Benefits

There is an ongoing shift in emphasis from energy efficiency metrics to GHG emission reduction metrics by government agencies, industry organizations, and other stakeholders aspiring to a zero-carbon future. To achieve these targets, decision-makers are increasingly leaning toward electrifying new and existing buildings. CMIC activities demonstrate parallel cost-effective pathways toward deep decarbonization. CMIC tools and activities develop technical information enabling stakeholders to document the benefits of direct natural gas, propane, low-carbon and renewable fuel use.

Technical Concept & Approach

The team will continue to coordinate CMIC activities and information products with other GTI Energy carbon management initiatives, specifically through continued technical analysis of gas system methane emissions and use of research findings from the Center for Methane Research (CMR) OTD project 6.16.a in CMIC tools and analyses, Net Zero Infrastructure Program (NZIP), and through collaboration with GTI Energy's ESM group. The team will engage with external organizations who develop tools to define decarbonization pathways to ensure that all viable future energy sources and beneficial end-use options are evaluated for decision-making.

The team will collaborate with EnergyPlus developers (GARD Analytics) to perform updates to the CMIC analytical tools, including new housing models and equipment, time-of-use analysis and marginal emission factors; adding emerging high efficiency electric, gas, and propane technologies; performing annual updates to grid mixes, prices, methane emission factors, and upstream efficiency of fuel pathways from eGRID, EIA, GHGI, and GREET respectively; and expanding renewable gas and hydrogen blending options.



Currently, 25 states and DC have targets for economy-wide GHG reductions for 2030 and beyond with over half of those being set since 2018. Source: C2ES

The team will also continue ongoing meta study analysis of electric grid projection scenarios and pathways from Cambium, EIA, and other modeling analysis to inform stakeholders on how they stack up to one another with comparison of their input assumptions and output results. The team will continue engagement and discussion with EIA's AEO modeling staff and follow up on identified action items from AEO working group session discussions. The team will also engage national labs such as NREL, Argonne, and others to incorporate GTI Energy developed datasets into datasets crucial for economy-wide modeling. Additionally, the team will provide support to stakeholders participating in select ASHRAE building standards and other standards, codes, and regulations.

Results/Status

The team launched modernized CMIC modeling tools: the Source Energy and Emissions Factors Modeling Tool, Residential Module (formerly EPAT), and Commercial Module (formerly SEEAT). The legacy tools were sunset and a new website was developed as a clearinghouse of information. The tools received 2024 updates to eGRID grid mixes and emissions, EIA prices, and methane emission factors using GHGI.

The team completed background analysis on the NREL Cambium vs EIA AEO meta study and was

analyzing demand growth projections across the models. Preliminary findings show differences in demand growth across models (~30%) and ~65% difference in peak capacity, with aggressive renewable capacity build out in the Cambium Mid-Case scenario vs AEO. The study also found that while policies and codes push for all-out electrification, the scenarios used from the models are not assuming exclusive electrification. The team also documented EIA's AEO working group notes and identified issues and action items, including H₂ demand and blending not modeled in end-use and missing hybrid, advanced gas heating systems.

The team is active in a Decarbonization Working Group (AGA/APGA/Utilities), collaborating on codes, standards, and policy issues via regular meetings. The team engaged with commercial building standard 90.1 on eligibility of advanced gas-fired equipment and submitted a technical dataset to 90.1. The team has direct and indirect participation in 10 influential committees, addressing issues around electrification, full-fuel cycle GHG emissions, preclusion of NG infrastructure, restrictions on RECs for RNG supply, and low carbon fuel use in buildings.

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Quality Audit Program for Natural Gas Utility Suppliers

This program provides gas utility operators with a mechanism to collaboratively audit suppliers' quality-management systems. Experts conduct independent and unbiased assessments on behalf of participating operators to provide a reliable and standardized approach for assessing suppliers' quality management systems.

Project Description

Distribution integrity management regulations encourage utility companies to place a new focus on supplier and supply-chain quality. Identifying threats and mitigating risks starts with the manufacturing process.

Reducing supply-chain risk requires a comprehensive and well-coordinated supplier audit program to ensure that the integrity of the supply chain is controlled and that the supplier is following policies and procedures. While the need for enhanced quality audits and monitoring programs is increasing, the availability of resources to conduct these programs is decreasing due to a focus on operations and efficiencies.

The scope of GTI Energy's Quality Audit Program (QAP) is to audit selected suppliers using federal codes, industry standards (API, ASTM, ASME, MSS SP, NACE, CSA, and ISO), customer-specific, manufacturers' internal, and quality management system requirements such as ISO 9001 and API Q1.

Deliverables

The programs' deliverables will include individual audit reports and corrective action reports. Only program members are eligible to receive the audit findings reports. GTI Energy will also track suppliers' performance against metrics and follow up on identified deficiencies and corrective actions. An annual workshop will be held to summarize audit findings and prepare a preliminary list of potential candidates for the following year's audits.

Benefits

Participation in a collaborative audit program provides value by creating efficiencies and cost savings by consolidating audits into one program, increasing the number of audits performed, creating leverage and increasing influence with suppliers, utilizing certified auditors with extensive experience, providing high-quality audits with consistency and standardization of the audit methodology, and allowing internal resources to focus on the core business rather than auditing.

Technical Concept & Approach

The suppliers included in the program audits are selected by the program members at the beginning of each year based on commonality of use, past performance, and ongoing quality issues. The audits performed are based on the process approach methodology of the ISO 9001:2015 Quality Management Systems per the requirements and inquiries from sponsors. Since 2015, the criteria/scope of the audits changed to focus more on industry standards and utility requirements.

On average, up to 19 processes are covered at each supplier site, including specific manufacturing and quality management system processes.

Each audit may take between two to three days based on the size of a site. Audits are performed by one auditor who may be accompanied by a Sponsor. The audit process is a combination of performance and compliance-based audits (verifying evidence of compliance versus reviewing actual performance).

All data related to this programs activities is maintained in Onspring, a database de-signed specifi cally for the program. Customers have unlimited access to this application, including audit schedules, audit reports, correc-tive actions, metrics, and more.

Metrics for suppliers are being de-veloped and monitored throughout the program. Examples of metrics

include vendor performance scores, audit report turnaround time, number of corrective actions created, time for corrective action closure, number of overdue corrective actions, etc.

Results/Status

A new ranking system was created to quantitative-ly assess suppliers' quality systems and to show the strengths and weaknesses of the organization. These scores can be used as a reference in deter-mining whether the company is making improve-ments going forward.

The project team planned and executed the annual Supplier Quality Audit Workshop hosted by South-west Gas on November 2024 in Las Vegas, NV. During the workshop, the project team presented the results of completed 2024 audits and discussed the names of potential sites for the 2025 audit cycle and improvements to the program.

In 2025, the team completed 14 quality audits as planned. The team also published reports and



"At Southwest Gas, safety and quality are at the heart of our core values. That's why we appreciate the OTD Quality Audit Program and the additional assurances it provides. With OTD, we know that critical gas carrying component manufacturers have controls in place to ensure the quality of the products we purchase. By ensuring that manufacturers' quality programs are robust and controlled, and that products are only purchased from top-notch suppliers, Southwest Gas can continue to provide safe and reliable natural gas service to the communities we serve."

*- Cynthia Davis
Operational Quality Assurance Manager
Southwest Gas Co.*

reviewed the results of audits performed with cus-tomers when appropriate.

The project team planned and executed the annual Supplier Quality Audit Workshop hosted by PG&E on November 5, 2025 in San Ramon, CA. During the workshop, the project team presented the results of completed 2025 audits and discussed the names of potential sites for the 2026 audit cycle and improvements to the program.

The team will finalize the list of suppliers for the 2026 audit cycle, start contacting vendors, and schedule audits. The team will implement updates in Onspring and conduct Onspring re-training if needed. The team will continue working with vendors to close their pending corrective actions from the audits completed in 2025.

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Center for Methane Research (CMR)

The CMR collects, analyzes, and interprets technical information on methane emissions, atmospheric concentrations, and global warming potential, disseminating findings to members and stakeholders. This information supports the development of corporate environmental strategies and scientifically based regulations and policy for the natural gas industry.

Project Description

The Center for Methane Research (CMR) was established to provide a centralized, industry wide technical and policy support resource focused on the presence, measurement, and potential impacts of methane in the atmosphere. The strategic approach to achieving this goal includes adopting a “good science / common sense” philosophy that addresses the end to end process of natural gas exploration, production, processing, transportation, delivery, and ultimately end use. Development of this “wellhead-to-burner-tip” industry resource provides a common platform of technical understanding that can be used in the decision making process in support of balanced policy decisions that impact the environment, industry, and ultimately the consumer.

Methane is the primary component in natural gas and is an important greenhouse gas that is 28 to 88 times stronger than CO₂ depending on the global warming potential time horizon used. Numerous studies from research organizations, academic institutions, federal and state agencies (e.g., DOE, EPA) and international organizations such as the IPCC focus on issues related to climate change and GHG emissions. With a vast amount of information and data, some of which are contradicting, there is a need to understand how these studies relate and how the large amount of data can be leveraged to gain an improved understanding of atmospheric methane concentrations and its relationship to activities of the natural gas industry.

The CMR objectives include acting as a liaison between industry, university, and government research organizations, regulators, and other technical experts; providing transparency and accessibility of the best available technical information and fit for purpose communication tools; establishing a centralized approach to data collection and analysis and an information repository; and providing ongoing evaluation of information gaps and fa-

cilitating development of new research efforts to bridge them.

Deliverables

Deliverables for this project include workshops, webinars, and video presentations on topics of interest to CMR members and community; the public website at <https://www.gti.energy/cmr/> with an updated emissions calculator; newsletters, press releases, and social media posts; summary updates and alert emails on relevant topics; and white papers and technical fact sheets on important findings pertaining to methane emissions.

Benefits

CMR acts as a reliable authority to find, distill, interpret, and disseminate the information which can then be used by members, stakeholders, and decision makers to develop the most environmentally beneficial and economically feasible policies and regulations. The CMR plays an active role in interpretation of data to address specific member and stakeholder needs or knowledge gaps essential for the industry to maintain its social license to operate.

Stakeholders can leverage the gathered CMR information and research data to obtain an improved understanding of how their product impacts global warming and the position of natural gas against other sources of energy, as they develop their corporate environmental and business strategies.

The information can also be used to support the development of reasonable and scientifically based environmental regulations and policy for the natural gas industry that enables continued growth and relevance as a key energy source.

Technical Concept & Approach

The team will prepare and present workshops, webinars, and video presentations on topics of interest to members and the community, interact-

ing with members for feedback and participating in forums, conferences, and workshops to stay on top of useful information. Topics include methane measurement uncertainty, key concepts in detection vs quantification, differences between measuring and monitoring emissions, landfill methane emissions, and exploration of models for methane emissions.

The team will also maintain and produce new public content for the website at <https://www.gti.energy/cmr/>, including newsletters, press releases, and social media posts. This effort will also focus on the maintenance of the emissions calculator available through the public CMR website.

Additionally, the team will constantly monitor new methane emissions studies and relevant policy news. The team will collect information on methane emissions with a focus on the natural gas industry, atmospheric concentrations of methane, global warming potential of methane and related GHGs, and new measurement techniques that may be useful to the industry. The team will provide update alerts and emails on relevant and important topics. The team will also work closely with CMR members and research partners (e.g., university labs, contractors, NGOs) to develop new white papers and technical fact sheets where needed to respond or explain new important findings pertaining to methane emissions.

Results/Status

In 2024, efforts focused on four key areas: Renewable Natural Gas methane emissions (white paper and webinar); changes to methane emission through pipeline replacement (white paper and webinar); Hi-Flow 2 device evaluation (webinar); and 5 regular update emails summarizing 49 papers and reports and 43 projects, statements, and articles. The CMR also performed a refresh to the public facing website to make access easier.

In 2025, GTI Energy secured nearly \$250M in DOE and EPA funding for four projects under the Methane Emissions Reduction Program (MERP), with CMR staff involved as principal investigators and contributors on the SE-MEQ and WELL Check projects.

The team attended CERAWEEK, the Methane Trailblazer Summit, and EEMDL's 2nd Annual Event, and presented on extrapolation approaches for creating measurement based methane emissions inventories. CMR contributors also presented at the American Geophysical Union Annual Meeting in

New Orleans on crewed aerial methane measurement, space based leak survey technology performance testing, and methane detection comparisons. Webinars covered hydrogen life cycle climate impacts, hydrogen leakage life cycle assessment, and upstream methane emissions inventories.

The CMR published a paper on uncertainty in drone based methane emission measurements, a PHMSA Inspection and Enforcement Priorities brief, and a PHMSA policy brief on gas pipeline leak detection and repair rules. The team added a new Timeline of Natural Gas Pipeline Regulations resource and a Relevant Articles section to the website, and participated in IPCC report review.

Regular newsletters summarized regulatory and research developments organized into Regulation & Policy, Distribution, and Upstream categories. Regulatory items included EPA proposals to eliminate GHG limits on power plants, PHMSA's final rule on pipeline leak detection, repeal of the Biden era Waste Emissions Charge, EU methane import regulations, EPA's proposed repeal of the 2009 endangerment finding, PHMSA rescinding Biden era pipeline inspection guidance, the UNEP methane progress report, FERC Final Rule on gas infrastructure permitting, and IEA's Pledges to Progress 2025 assessment of 116 oil and gas companies. Research summaries spanned pipeline leak characterization, LNG export environmental assessments, satellite based methane monitoring, leak detection and repair technologies, hydrogen blending effects on fugitive emissions, methane emission source distribution in the U.S. oil and gas sector, mobile survey performance under varying soil conditions, underestimation of emissions in urban and non-producing well contexts, multi-scale plume detection methodologies, unaccounted-for gas detection, hydrogen mixing risks, methane emission modeling, and top-down versus bottom-up emission estimation discrepancies.

The CMR continues as a subscription program. 2026 priorities include a workshop and white paper on "ALDP and 5PPM: Lessons and Opportunities for the Industry," expanded regulatory tracking, and deeper dives into measurement informed inventories and sector specific mitigation planning.

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Hydrogen Emissions Research Consortium (HyRes)

Researchers will build a foundation of sound, science-based information on hydrogen emissions, develop an R&D roadmap to fill gaps in the field, and conduct empirical measurements of hydrogen emissions to provide the information needed to make informed decisions on hydrogen emission mitigation strategies.

Project Description

HyRes will build a foundation of knowledge and establish targeted efforts to quantify hydrogen emissions, focusing on two areas: Research and Education and Hydrogen Emissions Quantification.

Hydrogen has the potential to help decarbonize difficult sectors while taking advantage of existing energy infrastructure. However, associated emissions and newly identified climate impacts of hydrogen in the atmosphere present a risk to the development of a hydrogen economy. To ensure a streamlined and low-impact implementation of a hydrogen economy, extensive lessons learned from the methane emission quantification and mitigation space must be applied to the topic of hydrogen emissions.

There is growing consensus in the scientific community that hydrogen acts as an indirect greenhouse gas with a global warming potential approximately 12 times that of CO₂ over a 100-year period. Very little data exists on hydrogen leakage and venting rates, with almost no empirical data available today. Hydrogen emission estimates throughout the value chain range widely from 0.2% to 20%. HyRes has been established to act as an information and education organization that will build a foundation of sound, science-based information on hydrogen emissions and the potential atmospheric and climate impacts of those emissions.

Deliverables

Deliverables for this project include presentations and reports on hydrogen emissions research shared with members, an annual meeting focused on hydrogen emission issues, an R&D roadmap identifying gaps in the field of hydrogen emissions, hydrogen emission inventories developed in collaboration with academic and industrial stakeholders, and guidelines and requirements for tools to measure hydrogen emissions.

Benefits

Hydrogen has the potential to help decarbonize difficult sectors while taking advantage of existing energy infrastructure. However, associated emissions and newly identified climate impacts of hydrogen in the atmosphere present a risk to the development of a hydrogen economy. HyRes will provide the information needed to help ensure cost efficiency through informed decision making on hydrogen emission mitigation strategies.

Technical Concept & Approach

The project will focus on two areas: Research and Education and Hydrogen Emissions Quantification. The effort to address these areas is broken down into five tasks spanning information gathering, roadmap development, emission inventories, quantification technologies, and emission measurements.



HEX@TEX Workshop

Researchers will harmonize the research conducted so far in the LCRI and CMR projects and create presentations and reports to share with members. This effort will foster continual communication between the research community, members, and other stakeholders. Researchers will also participate in forums, conferences, and workshops to stay on top of useful information, and will host an annual meeting in the Fall focused on the biggest hydrogen emission issues. Learnings from these activities will feed into the development of an R&D roadmap identifying gaps in the field of hydrogen emissions. The roadmap will be maintained and updated as the understanding of hydrogen emissions evolves and new advancements in hydrogen detection technologies and schema are developed.

Additionally, researchers will collaborate with academic and industrial stakeholders to develop protocols and plans to create hydrogen emission inventories. Work will include assembly of information on all potential leak points across the hydrogen industry, initial estimates of emissions rates, and updating of those inventories as more information becomes available. Researchers will also build upon GTI Energy's expertise in hydrogen safety technologies and practices to evaluate existing

tools to measure hydrogen emissions, and will create guidelines and requirements for developing new tools. The team will work with technology developers and commercializers to facilitate bringing new technologies to market for field quantification of hydrogen emissions. Researchers will also partner with industry to conduct empirical measurements of hydrogen emissions.

Results/Status

The team published a paper in *Nature Communications Earth & Environment* titled "Effect of Hydrogen Leakage on the Life Cycle Climate Impacts of Hydrogen Supply Chains." A second paper, "Estimating the Climate Impacts of Hydrogen Emissions in a Net-Zero U.S. Economy," was also accepted in *Progress in Energy*. Results show that hydrogen emissions, when converted to CO₂-equivalent over a 100-year time horizon, are always lower than CO₂ emissions and usually less than CH₄ emissions, contributing 1-14% of total CO₂e emissions in net-zero scenarios with fossil fuels and 22-45% in scenarios that restrict fossil fuels.

The team organized the inaugural HEX@TEX workshop on hydrogen sensing and hosted HEX@TEX 2025 at the University of Texas at Austin, drawing over 60 attendees from around the world. The event included tours of the H₂@Scale Hydrogen ProtoHub, which features a controlled hydrogen release mechanism serving as a real world testing site for hydrogen sensor developers, and the Bureau of Economic Geology hydrogen facilities. Additional activities included presenting at the European Geosciences Union Meeting, beginning a hydrogen industry emissions map, assembling an information library, and serving on advisory boards for HYWAY and OPTHYCS. The team is assembling a hydrogen sensing group made up of hydrogen sensor developers and users across the globe.

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METHANE EMISSIONS/ DETECTION & GAS QUALITY

Significant initiatives in this area are addressing greenhouse-gas issues, methods for estimating pipeline leak emissions, and remote gas sensing and monitoring. Research teams are also investigating gas-imaging techniques, biomethane monitoring, robots, drones, and various sensors and methane-detection devices.

Results from these efforts help companies to reduce operations costs, minimize environmental impacts, and more cost effectively comply with regulations.

Residential Methane Detectors Program

Researchers will evaluate residential methane detectors through laboratory testing, consumer studies, and a nationwide pilot program, supporting development of the NFPA 715 standard and the reduction of the UL alarm threshold to 10% LEL methane in air. This work will enable utilities to provide validated guidance on in-home fuel gas detection.

Project Description

The Residential Methane Detectors Program will evaluate commercially available residential methane detectors (RMDs) for susceptibility to false positives from common household chemicals and assess consumer behavior and awareness. The program will also include a year-long pilot study installing around 1,000 detectors in homes and further interference and responsiveness testing of new methane detectors emerging on the market.

In later phases, activities will focus on a consumer behavior study to better understand how customers react to potential leaks and the development of a fit-for-purpose standard for residential methane detectors. OTD will also participate in the National Fire Protection Association (NFPA) 715 committee writing of a new standard regarding fuel gas detection and UL committee 2034 that has jurisdiction of UL Standard 1484 on fuel gas detectors.

Deliverables

The deliverables for this program include: 1) A fit-for-purpose methane alarm threshold determination; 2) a revised standard testing protocol; 3) two consumer behavior studies; and 4) pilot study and recommendations, and (5) numerous tests on interferences from common household products.

Benefits

The results of this research allow utility companies to add to their environmental and safety public-awareness programs by offering technically validated information regarding the reliability and enhanced safety that in-home methane detectors can provide.

Technical Concept & Approach

Specific tasks in this project include:

Consumer Behavior Study

Although RMDs are currently available, there is not widespread adoption and a general lack of awareness of these safety devices exists. This type of study complements existing market research on low customer adoption of gas detectors and customer responses in regards to leaks. The study looks at issues such as limitations in knowledge, consumer motivation, and decision making. These insights can be used to help utilities develop appropriate strategies to increase the effectiveness of both natural gas odorant and residential methane detectors.

Development of Appropriate Detection Level and Fit-for-Purpose Standard

The team will determine through testing that a 10% LEL of methane in air can be met by several manufacturers of detection devices. Using the results, the team will participate in writing the new NFPA 715 standard and updating UL 1484.

Pilot Study

A pilot program investigated the performance of detectors in actual home settings, consumer responses to alarms, and how effective the detection was.

False Positive Testing

Detectors will be exposed to common household chemicals to determine if they responded with a false alarm. Chemicals to be tested include household cleaning products, acetone, paint thinner, ethanol, and hairspray.

Results

NFPA 715 / UL Standards Development

The program began with assessing commercially available residential methane gas detectors for false positives from common household chemicals and identified the best-performing detectors. Testing was expanded to include international products and newly introduced detectors. A nationwide survey of about 1,000 people revealed low awareness and ownership of RMDs, with many confusing them with carbon monoxide detectors. In 2016, the team launched a pilot program installing around 1,000 detectors in homes. In 2018, the team recommended an alarm threshold of 10% LEL methane in air and contributed to drafting a new NFPA standard for fuel gases detection. The team also developed recommendations for optimal detector placement near potential leak sources. A second nationwide survey conducted by GTI Energy and a research partner collected 4,500 responses. Although detector ownership increased from 12.7% in 2016 to 29.2% in 2023, awareness decreased from 52.5% to 46.0%. Despite this, 90% of current detector owners remained interested in maintaining these devices.

In 2025, the second edition of NFPA 715 was published as a consent standard, and UL 1484 Edition 6 was published with a name change to “Fuel Gas Alarms.” Work has begun on harmonizing UL 2034 and CSA 6.19 and on the potential creation of a binational UL/ULC 1484 standard with Canada. NFPA 715 is now open for public input for its third edition, closing June 2026.

GTI Energy successfully supported the development and revision of NFPA 715 across two complete edition cycles, with the first edition published in 2022 and the second edition issued in early 2025. The second edition now references UL 1484 rather than specifying a threshold directly, and UL 1484 Edition 5 (published February 2022) had lowered the alarm threshold to 10% LEL.

False Positive Chemical Testing

A testing program evaluated selected natural gas detectors for potential false positive responses to household chemicals. For the metal oxide semiconductor devices, the chemicals most likely to respond were propane, acetone, ethanol, and



Test Chamber

occasionally other hydrocarbon containing chemicals. A later study found a partial positive response to Freon R410-A.

Utility Detector Evaluations

Evaluations of several residential fuel gas detector models were conducted for utility partners. Twenty detectors from one manufacturer were tested per a utility's natural gas detector acceptance protocol at 10% LEL and 12% LEL methane in air. Some detectors exhibited inconsistent alarm responses at 10% LEL, though most passed when retested at 12% LEL. A separate evaluation of a detector with a wireless hotspot device found it alarmed to 10% LEL methane and hydrogen sulfide mixed with simulated natural gas but did not respond to propane, 5% LEL methane, or household chemicals tested.

Three detectors from two other manufacturers were also evaluated. All three responded to 10% LEL methane and hydrogen sulfide mixed with simulated natural gas. Two of the three also responded to 5% LEL methane, 25% LEL propane, and common household chemicals. All passed the quality control challenge of 10% LEL methane after each exposure.

Status

All Final Reports through Task 10 were issued. Two new phases are beginning in June 2026.

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Assessing Performance Impacts of Blended Hydrogen on Thread Sealants

Researchers will study the impacts of hydrogen-blended natural gas on thread sealants typically used on meter set assemblies (MSAs). The findings will give operators a baseline understanding of how thread sealants perform with hydrogen blends, allowing risk management as blending adoption increases.

Project Description

The use of hydrogen and hydrogen-natural gas blends in traditional natural gas networks has increased in recent years. Operators are seeking to better understand and manage the risks associated, including the longer term effects of hydrogen on transmission and delivery equipment. Hydrogen molecules have a smaller molecular weight and size than natural gas. Due to the difference in molecular size, it was of interest to explore whether threaded connections with sealants remain leak-tight when a hydrogen blend is used.

Deliverables

Deliverables for this project include a final report detailing observations and findings.

Benefits

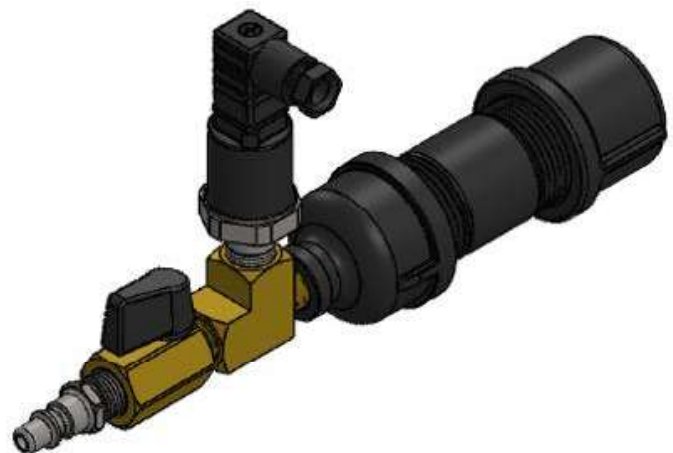
As the use of hydrogen-blended natural gas increases, it is important to understand and manage potential risks that may arise. This project will establish a baseline understanding of the effect that hydrogen-blended gas has on sealants within delivery infrastructure.

Technical Concept & Approach

The initial plan was to simulate meter set assemblies' working conditions and use threaded assemblies with sealants as a part of the hydrogen flow rig. However, due to delays in the fabrication of the hydrogen rig (OTD 5.21.t), the plan has changed, and the threaded fittings with sealants will be evaluated using pre-blended cylinders. Testing will focus on the performance of various thread sealants in a hydrogen blend of 80% NG and 20% H₂. The project team will analyze results and compare the impacts of blended and non-blended gases on samples.



Black Steel 1 NPT Test Sample (1 NPT to 1/4 NPT Reducer – 3-in Long 1 NPT Pipe Nipple – 1 NPT Cap)



Pressure Transducer Subassembly attached to Black Steel 1 NPT Test Sample

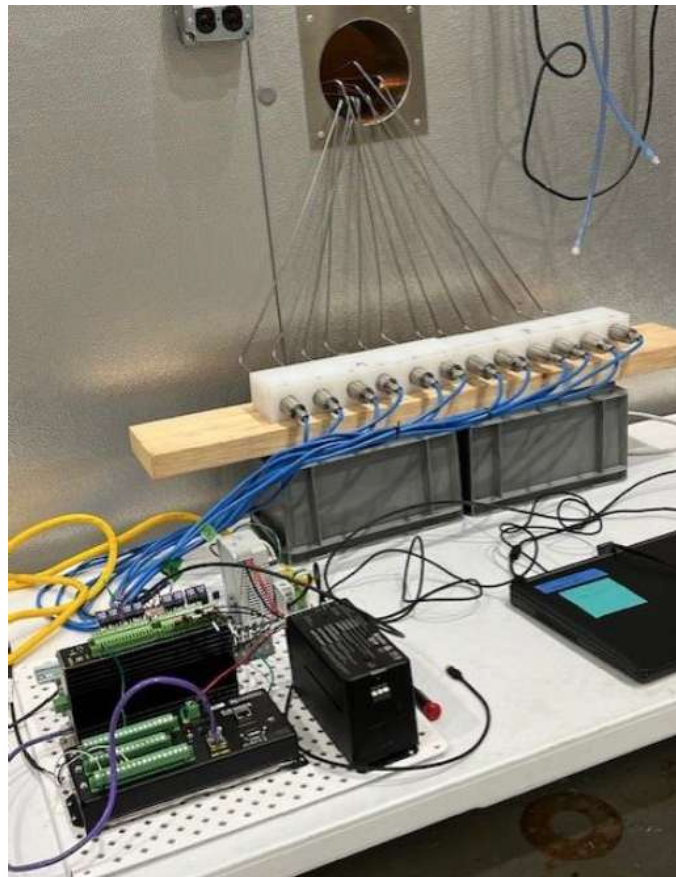


Test samples inside of the temperature chamber

Results/Status

The evaluation consisted of assembling identical pipe sample assemblies with 8 different thread sealants. All threads were verified for compliance with relevant standards using thread gauging prior to sample construction. Once constructed, half of these samples were pressurized with 60 psig of methane and the other half were pressurized with 60 psig of an 80/20 blend of methane and hydrogen. All samples were pulled under a vacuum prior to pressurization to avoid entrapment of air in the samples and were leak-checked before moving into a temperature cycle. The internal pressure of each pressurized and isolated sample was continuously logged over the course of the ten-day temperature cycle to monitor for pressure loss due to a leak developing over time.

Four sealants performed favorably (100% passing rate) for samples pressurized with both methane and an 80/20 blend of methane and hydrogen. Three sealants performed favorably (100% passing rate) for samples pressurized with methane and less favorably (less than 100% passing rate) for samples pressurized with an 80/20 blend of methane and hydrogen. One sealant performed less favorably (less than 100% passing rate) under both gas types.



Data logging configuration using intrinsically safe pressure transducers for each test sample

When examining the overall difference between samples pressurized with methane and samples pressurized with the 80/20 blend of methane and hydrogen, the team observed a 4% failure rate for samples filled with methane and a 29% failure rate for samples filled with the 80/20 blend of methane and hydrogen. Though several sealants were found to successfully remain leak-tight regardless of gas type, the team observed a general tendency for samples pressurized with an 80/20 blend of methane and hydrogen to be more likely to leak over time than samples pressurized with methane. Methane samples achieved a 96% pass rate (22 of 23), while samples pressurized with the 80/20 blend achieved a 71% pass rate (17 of 24).

This project is complete. A Final Report was issued in June 2025.

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Veritas Methane Emissions Measurement and Verification Initiative

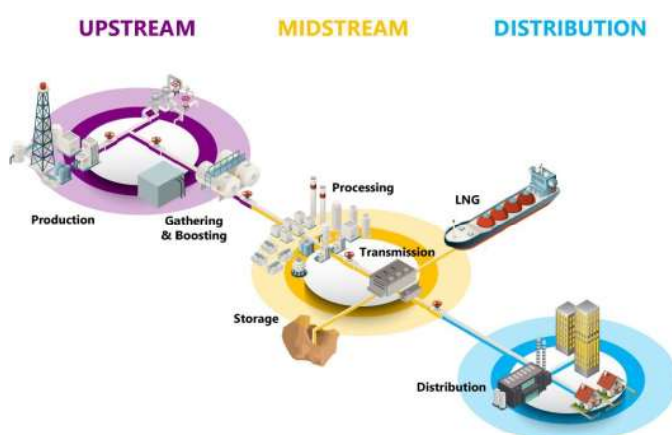
The team will develop and refine standardized, technology neutral protocols for measuring and reporting methane emissions across the natural gas supply chain. Widespread adoption will result in consistent, trustworthy data that investors and other stakeholders can rely on for comparing emissions performance across supply chains.

Project Description

Accurate measurement is the first step towards demonstrating credible reductions of methane emissions. The goal of Veritas is to provide a standardized, technology neutral, open-source methodology to guide the industry on how to measure and calculate accurate methane emissions. Veritas provides specific technical protocols that are technology agnostic for each segment of the natural gas industry to measure methane emissions in a consistent, credible, and comparable way. Veritas covers six segments of the oil and gas industry — production, gathering & boosting, processing, transmission & storage, distribution, and LNG — combining them as upstream, midstream, and distribution.

Deliverables

Deliverables for this project include the Veritas protocols and updates, the Veritas website, whitepapers on project learnings, published documents addressing uncertainty in emissions measurement and quantification and data collection, and a communications strategy to facilitate stakeholder awareness and understanding. 2025 deliverables include the Upstream Site Level Aerial Measurement Informed Inventory Decision Tree and updates to the Supply Chain Intensity Protocol and Assurance Protocol.



Benefits

Widespread adoption of the Veritas protocols will result in consistent, trustworthy data that investors and other stakeholders can rely on. By establishing a standardized methane measurement methodology, companies, investors, and policymakers will have an accurate inventory of methane emissions that can be compared across supply chains for collaborative reductions.

The Veritas protocols are the building blocks to provide global confidence in the climate credentials of natural gas. The protocols provide companies with guidance on how to measure their methane emissions and reconcile current emission factors with actual measurements. This will allow companies to reduce their methane emissions, participate in certification schemes, and meet import or procurement requirements that are tied to methane intensity more effectively.

Technical Concept & Approach

Veritas provides specific technical protocols that are technology agnostic for each segment of the natural gas industry to measure methane emissions in a consistent, credible, and comparable way. The Veritas framework includes several sequential documents that address different aspects of this goal, including the Measurement & Reconciliation Protocol, the Methane Emissions Intensity Protocol, the Supply Chain Intensity Protocol, and the Assurance Protocol.

The team will work with industry leaders to continue testing and refining these protocols which cover all segments of the natural gas supply chain — upstream, midstream, and distribution. Technical Project Committee meetings and workshops will be conducted to gather feedback and white papers and demonstrations will be used for educational outreach and sharing project learnings.

Results/Status

Veritas Version 1 was published in February 2023 and Veritas Version 2 of the protocols was published in December 2023. (<https://veritas.gti.energy>)

The Veritas protocols have been tested and refined by industry leaders and cover all segments of the natural gas supply chain – upstream, midstream, and distribution. These technology-neutral protocols provide practical tools to accurately measure total emissions, helping companies to enhance efficiency, strengthen operations, and reduce waste.

To develop the protocols, GTI Energy worked with a diverse group of stakeholders to ensure the methodology is widely accepted and adopted, including academics, environmental NGOs, companies, investors, policymakers, and vendors. By publishing, updating, and refining these proven protocols and making them open-source, Veritas delivers a straightforward, results-oriented approach for companies to demonstrate progress on methane emissions reductions.

GTI Energy maintains these protocols as open-source, technical tools that can be deployed and operationalized by different stakeholders around the world. Veritas Version 2 offers a simplified framework to evaluate and respond to the mounting volume of data on methane emissions.

2025 Veritas work products include the Upstream Site-Level Aerial Measurement-Informed Inventory Decision Tree and updates to the Supply Chain Intensity Protocol and Assurance documents.

The Upstream Site-Level Aerial Measurement-Informed Inventory Decision Tree provides a pathway to obtain a top-down measurement-informed emissions inventory (MII) from crewed aerial data set(s) in combination with optional auxiliary operator data. Though centered on aerial flight campaigns to measure site emissions, the decision tree allows flexibility to isolate specific emission events that may not be well characterized in an aerial measurement to obtain a robust estimate of total emissions.

The decision tree gives an operator pathways to create a MII by incorporating optional operator data, such as activity logs, component counts, engineering measurements and calculations, and/or historical emissions; incorporating rare event emissions, leveraging probabilistic modeling or supplemental measurement data; Adjusting for

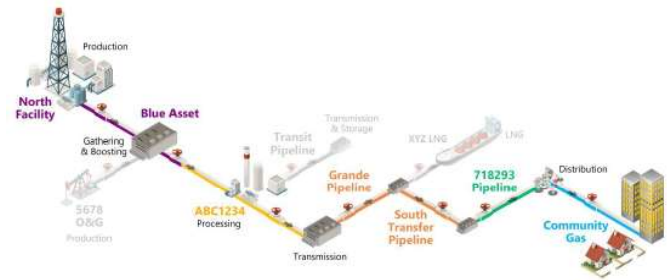


Illustration of example defined supply chain, production to point of custody transfer, defined here as delivery to local customers (gas exiting the distribution system).

limitations of the measurement technology, using statistical or engineering-based approaches; and Applying extrapolation methods (Temporal and Spatial Extrapolation) to estimate emissions across time and unmeasured assets.

The Supply Chain Intensity Protocol builds upon the separate asset-level Methane Intensity Protocol and provides a framework for estimating the EI (emission intensity) across the natural gas supply chain. In this protocol, use of EI is referencing asset-level emissions intensity, not segment-level. This Supply Chain Intensity Protocol uses the EIs calculated in the Methane Emissions Intensity Protocol to calculate a total EI for a defined supply chain from production to a specific custody transfer point, for a quantity of gas traveling a specific pathway to reach that point, traveling through assets that may be owned by a single company or multiple companies. The supply chain EI may be used for comparing the methane emissions performance of different operating supply chains.

The Assurance document ensures companies effectively implement and adopt the Veritas protocols. Although the adoption of the Veritas initiative is optional, if a company decides to adopt it fully, they shall ensure that the Assurance Protocol is followed. This document provides the minimum requirements from Veritas Measurement and Reconciliation Protocols for Pathways 1, 2, and 3. Pathway 1 is the Measurement-Only pathway, Pathway 2 is the Hybrid pathway, and Pathway 3 is the Source-Level OGMP 2.0 aligned pathway. It provides the steps and instructions for following the protocols, the criteria for adoption, and other information on implementing the protocols.

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Evaluation of Current Advanced Mobile Leak Detection Systems (AMLD) Phase 2

Researchers will conduct controlled natural gas releases and participate in blind surveys with LDCs to better understand how findings on advanced mobile leak detection (AMLD) performance and limitations from prior controlled testing apply to actual field conditions. This project will provide guidance on factors that can influence leak find rates, for use in evaluating potential vendors and mobile survey processes.

Project Description

The primary objective of this project is to better understand the performance of advanced mobile leak detection (AMLD) systems in real world scenarios. This Phase 2 project will expand on the controlled testing findings in Phase 1 to better understand how those findings of leak detection performance and limitations apply to actual field conditions, and to provide guidance to sponsors on factors that can influence leak find rates for AMLD.

The PIPES Act of 2020 established the expectation that advanced leak detection technologies, such as AMLD, be incorporated into LDC leak survey programs. Operators seeking to use advanced technologies to make sound judgements on potential survey technologies and their best applications.



Instrument installation on vehicle.

In response, several AMLD systems have emerged offering performance claims.

Deliverables

Deliverables for this project will include a formal test plan incorporating controlled releases and single blind and double blind real world field tests, as well as a blind AMLD field test protocol. A final report encompassing the results, conclusion and recommendations will also be submitted.

Benefits

AMLD performance in the field can vary from results observed under controlled testing conditions. A better understanding of AMLD performance aides LDCs that are currently deploying or considering deploying AMLD systems into their current operations. This Phase 2 study will examine differences in AMLD system performance between controlled studies and field deployment conditions. The project will ultimately provide guidance that can be used to evaluate potential vendors, demonstrate results within a company, and evaluate mobile survey processes for effective deployment.

Technical Concept & Approach

The project will focus on working with LDCs that are currently using AMLD as part of their survey program. The team will identify two or three LDCs with differing field experiences that are willing to host field testing.

A detailed test plan will be developed that incorporates controlled releases, single blind and double blind real world field tests that shield the test participants from knowing they are participating in the project. Single blind testing will be used on verified known leaks, where a pre-walking survey would be done to establish that known leaks are currently detectable. Randomized no leak locations will also be used to establish any false positives. Double

blind surveys will be in coordination with the LDC planned leak survey and follow up indication investigation.

Based on the agreed test plan, the team will work with the LDCs to complete the testing, which will require participation from sponsors. It is anticipated that the testing will take place in a series of one week segments for a total of four weeks in the field. Adjustments to the test plan may be made as testing progresses to accommodate unforeseen issues or results.

Preliminary field test data will be analyzed on the first rounds of field testing. Assessment will be made to determine what follow up testing may be required to fill in data holes or to conduct further testing on issues that are not well understood. It will also be used to identify the difference in performance from controlled testing to actual field conditions.

Field situations identified during data analysis will be explored in a follow up round of field testing, which will also include planning, design, and analysis of additional data collected. This follow up testing can be used 1) to collect additional data, 2) to perform more specific testing on factors identified during data analysis, 3) to increase sample sizes if needed.

Results/Status

Phase 2 began, and initial work involved reviewing the Phase 1 results and methods as well as the current academic and commercial AMLD literature. A summary of the literature review has been prepared. The presentation of the Phase 1 results was updated to support an understanding of the factors that impact AMLD generally rather than a comparison across vendors. .

User group meetings began with the goal of discussing lessons learned or current challenges sponsors are experiencing. The first user group meeting was conducted with productive conversations, and separate 1:1 meetings with individual sponsors were held after; these meetings have helped guide the desired scope and direction of the project. A series of survey questions was also developed to help the team better understand the interests and concerns different sponsors have regarding AMLD and their willingness to participate in field testing.

An initial field test plan has been developed based on previous OTD projects 7.22.j AMLD Phase 1 and 7.23.n Satellite Methane Detection for Distribution Applications. The plan currently includes a test plan focused on understanding the increased find rate of follow up investigations based on AMLD indications and follow up investigations without an AMLD indication. A high level summary of the field test plan was prepared and introduced in the user group meetings to identify sponsors interested in participating and clarify the test method and main results expected. A separate document that presents a simplified version of this test plan is being prepared as a guide for sponsors to use in their own AMLD testing. Both the field test plan and the testing guide are actively being developed.

Sponsors will be informed about the needs for the field test plan in the next user group meeting and asked to conduct a survey so that individual sponsor meetings can be scheduled with those willing to participate in the field test. Discussion of the time and location for testing will continue in 2026.

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Open Hydrogen Initiative

The team will develop tools and research to support accessible, technology-agnostic hydrogen and clean fuels markets, including expanded emissions-accounting capabilities for ammonia production and hydrogen transportation. This work will provide natural gas LDCs, midstream companies, hydrogen producers, and other market participants with facility-specific, transparent carbon intensity assessments to support investment, operational, and market decisions.

Project Description

The Open Hydrogen Initiative (OHI) is dedicated to developing foundational tools and research to support accessible, unbiased, and technology-agnostic hydrogen and clean fuels markets. As a global coalition comprising gas and power utilities, oil and gas companies, environmental NGOs, academic institutions, industry coalitions, and technology providers, OHI works to ensure that hydrogen market development is grounded in transparent, data driven methodologies.

As organizations around the world advance their energy transition strategies, hydrogen and clean fuels are emerging as important options for decarbonizing hard-to-abate sectors. These fuels also offer opportunities for the gas sector to support decarbonization while leveraging existing infrastructure and expertise. However, energy markets continue to lack a consistent and broadly accepted methodology for measuring carbon intensity. OHI addresses this challenge by developing credible, technology-neutral tools that provide facility-specific and transparent carbon intensity assessments, helping ensure that hydrogen and clean fuel pathways, including gas-derived pathways, can be evaluated on a consistent basis.

OHI has convened a diverse range of stakeholders involved in the hydrogen marketplace, including experts from integrated energy companies, gas and power utilities, environmental NGOs, government agencies, academia, hydrogen production companies, technology providers, and industry coalitions. OHI stakeholders actively contribute to the development and execution of initiative priorities through engagement with both OHI technical staff and leadership.

Since its public launch in September 2022, OHI has achieved several technical and coalition milestones. These include development and continued enhancement of the OHI Life Cycle Assessment

(LCA) Toolkit; expansion of the Toolkit beyond hydrogen production to include ammonia production and hydrogen transportation pathways; multiple white papers focused on clean fuel LCA best practices; 14 demonstrations of the OHI Toolkit; advancement of standardized contracts for hydrogen and clean fuel transactions; and engagement with government and industry stakeholders on the role of differentiated natural gas in clean hydrogen production.

The next phase of OHI's work will build on these successes through continued improvement and expansion of the OHI Toolkit and broader leadership across the hydrogen marketplace. A central focus will be expanding carbon-intensity accounting beyond hydrogen production to include ammonia production and hydrogen transportation pathways, including dedicated hydrogen pipelines, hydrogen blending into natural gas systems, and hydrogen trucking. OHI will also continue its emphasis on industry engagement, education, market infrastructure, and technical guidance.

Deliverables

Deliverables for this project will include expanded methodologies and unit process libraries supporting ammonia production and hydrogen transportation pathways, including dedicated hydrogen pipelines, natural gas blending, and trucking. These capabilities will be incorporated into updated versions of the OHI Toolkit and supporting documentation.

Additional outputs will include an overview of feedback and action items resulting from the public comment process, technical publications and peer-reviewed research, special-session webinars, and stakeholder engagement activities. The project will also deliver an improved User Guide incorporating new modules, methodologies, and best practices, along with ongoing updates to the OHI

Toolkit as needed.

Benefits

Existing frameworks for measuring carbon intensity often rely on industry averages, outdated data, or one-size-fits-all assumptions. These limitations can make it difficult for policymakers, investors, project developers, utilities, and other market participants to compare hydrogen and clean fuel pathways on a consistent basis.

The creation and adoption of science-based and industry-inclusive hydrogen and clean fuel carbon-intensity protocols will create a more consistent basis for comparing and valuing hydrogen and related fuels according to their environmental performance. Expanding the OHI Toolkit across production, conversion, and transportation pathways will also improve the ability to assess carbon intensity across a broader portion of the hydrogen value chain.

This work will advance transparency, encourage collaboration across the industry, and provide a technical foundation that can inform evolving market structures, standards, and policy. Widespread adoption and use of the OHI Toolkit can provide market participants with consistent and trustworthy data while supporting a more technology-inclusive hydrogen and clean fuels market.

Technical Concept & Approach

OHI will continue to expand the technical capabilities of its LCA Toolkit beyond hydrogen production. The team will develop methodologies and modeling capabilities for ammonia production, enabling users to evaluate the carbon intensity associated with converting hydrogen into ammonia across representative production configurations and energy inputs.

OHI will also enhance the Toolkit's hydrogen transportation capabilities. The team will evaluate emissions associated with transporting hydrogen through dedicated hydrogen pipelines, blending hydrogen into natural gas transmission and distribution systems, and transporting hydrogen by truck. For each pathway, OHI will develop the necessary emissions inventories, unit processes, and carbon-accounting methodologies and integrate these capabilities into the broader OHI modeling framework.

The resulting modules will undergo technical review, testing, validation, and quality-control activities to ensure that the expanded Toolkit remains

transparent, consistent, and usable across different hydrogen and clean fuel pathways.

The team will also conduct a public comment process to gather industry feedback and refine methodologies and will update the OHI User Guide to reflect the expanded capabilities of the Toolkit.

In parallel, OHI will continue to advance complementary market-development activities, including standardized contracting efforts, technical publications, workshops, webinars, special sessions, and other stakeholder-engagement activities.

Results/Status

The OHI Toolkit continued to advance throughout 2025, with Version 1.2 released in February 2025. This release improved result accuracy, clarified carbon-intensity pathways, incorporated updated scientific information, and enhanced guidance and usability. It built on Version 1.1, released in July 2024, which included improvements to data accuracy, user experience, modeling options, and the Toolkit interface.

During 2025, the OHI team also significantly expanded the scope of the Toolkit beyond hydrogen production. New capabilities were developed to assess ammonia production and multiple hydrogen transportation pathways, including dedicated hydrogen pipelines, hydrogen blending into natural gas systems, and hydrogen transportation by truck. These additions broaden the Toolkit's ability to assess carbon intensity across the hydrogen value chain and provide users with a more complete picture of emissions associated with hydrogen and hydrogen-derived fuels.

The OHI Methodology was selected as the default carbon-intensity methodology in the NAESB hydrogen contract development process, representing an important step toward integrating transparent carbon-intensity accounting into emerging hydrogen market infrastructure.

OHI also continued extensive engagement with industry, government, and other stakeholders through dedicated events, panels, webinars, special sessions, and technical meetings. The coalition continued to grow, adding new member organizations and expanding participation across the hydrogen and clean fuels ecosystem.

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Predictive Corrosion-Rate Risk Model from Soil and Environmental Conditions

Researchers will develop a quantitative risk assessment model to identify high corrosion potential in order to better understand the state of existing pipelines and more efficiently conduct maintenance.

Project Description

Environmental conditions, age of the infrastructure, and soil conditions are significant parameters which affect measuring, predicting, and mitigating corrosion. Other OTD and GTI Energy projects for PHMSA on the evaluation of external corrosion-rates have provided estimates of corrosion rates from soil properties and field data.

The team will develop a quantitative risk assessment model to identify high corrosion potential. The tool will be a web-based program using parameters based on their effect on corrosion potential and quantifying corrosion growth-rate estimates in a Bayesian model for a risk assessment of the pipe segment.

Deliverables

The main deliverable, along with the final report, is a risk assessment program for estimating corrosion potential based on corrosion rates. The assessment will assist in the decision making of mitigating the threat through monitoring, repair, or replacement of the affected segment. The tool will be provided in a web based program.

Benefits

The project presents an integrated approach for the evaluation, prediction, and mitigation of external corrosion risk. For belowground pipes, work investigates the effect of electro-chemical properties of the surrounding environment, including electrical resistivity, alternating current, moisture content, and soil properties. The outcome of the project incorporates corrosion inspection data and develops a corrosion growth-rate prediction model in a web-based software for risk assessment. Results from field data will be used to validate the corrosion potential of selected sites. This approach will help in identifying high-risk locations, monitoring procedures, and inspection intervals. The output would also help in recommending modifications to the leak/corrosion monitoring procedures. This ap-

proach mainly addresses corrosion in belowground lines. Atmospheric corrosion threat to aboveground facilities is affected by a different corrosion mechanism but may be added in follow on efforts.

Using this model, operators will have more insight into the state of their pipelines and will be able to more efficiently direct their resources when conducting maintenance. In addition, the Gas Distribution Integrity Management Program (DIMP) requires evaluating and ranking this risk to the pipeline system. CFR Part 192- Subpart O for pipeline integrity management also requires establishing a reliable estimation of corrosion growth-rate.

Technical Concept & Approach

Specific tasks in this project include:

Establish A Data Form for Corrosion Monitoring Procedures

Review corrosion and leak related data from previously recorded inspections. Categorize corrosion inspection (such as light, moderate, and severe corrosion), based on metal loss values when available. Estimate related soil conditions from soil survey records and utility records when available.

Correlate the Data System

Incorporate the data into a web based program linking historical data and field inspection sites with other soil and environmental conditions. Develop a user interface for data entry and search.

Evaluate Soil and Environmental Parameters

Correlate electrochemical measurements of corrosion potential to soil conditions to predict a growth-rate from measurements and historical data, including soil properties, pipe history, and field conditions into the correlation. Examples of anticipated field data include soil moisture content, pH, resistivity, permeability and drainage characteristics, chloride and sulfite levels, and soil Redox potential. Many of these parameters can be obtained from existing soil survey data.

Incorporate Data in a Web Based Risk Management Program

Develop a risk model to combine soil parameters and historical data with existing correlations in the literature between soil properties and corrosion potential. Develop a computer program to present the results of the analysis in a simplified format that provides estimated corrosion-rate and quantifiable risk assessment using a Bayesian Networking approach, including a user interface which allows the user to enter relevant site data to improve the reliability of risk ranking determination of the pipe segment.

Results/Status

The team first conducted analysis to determine that natural and outside forces are a larger threat to older cast iron pipes compared to gas distribution pipes more generally. The project developed a framework for pipeline external corrosion risk assessment. It consists of estimating the likelihood of pipe corrosion based on soil and pipe properties, and the consequences of pipe rupture within the leak-rupture boundary model analysis. Bayesian networks were developed for these two estimates based on primary pipe and soil characteristics to predict the likelihood of corrosion risk.

The estimate of pipe corrosion potential was developed based on relationships between the various soil and pipe parameters. This drew on a review of corrosion related soil and pipe properties based on historical and published field data. The soil characteristics included its type, moisture content, chemistry, and resistivity. The pipe conditions which affected corrosion potential included their coating type, condition, and cathodic protection. Soil corrosion is affected by many parameters including soil resistivity, water content, pH, soluble salts, oxygen concentration, soil chemistry, and microbial activities. Accordingly, corrosion rate in soil may change along the length of the pipe and it makes it difficult to obtain a single rate. The simplified model adds the effects of the various soil parameters independently, while in reality soil parameters interact together so that a change of a single parameter may affect the contributions of the other ones.

Pipe properties and flaw characteristics were linked to predict the likelihood of pipe leak or rupture. Building on an earlier GTI Energy study, the leak-rupture boundary analysis showed that shorter defects and lower operating pressures both increase the probability that a pipe failure will manifest as a leak rather than a rupture. This allows the

limit defect length or the limiting operating pressure to be estimated for a given pipe so that failures stay in the leak (repairable) regime rather than the rupture (replacement) regime.

The Bayesian Network analysis was implemented in a web based program using Agena Risk software. The user obtains the likelihood of external corrosion potential of buried steel pipes based on pipe condition and soil characteristics, and the probability of pipe rupture under a given operating pressure and a metal loss defect. The results of the program provide the user with a tool to make an informed decision of the corrosion potential and consequences for particular pipeline characteristics and soil conditions.

The project also assessed pipe rehabilitation options, which depend on operating conditions and the location and severity of the corrosion damage. They include metallic sleeves, wraps, cured in place liners, and composite pipes. Metallic sleeves and wraps are commonly used to control leaks and provide structural support to limited sections subjected to external corrosion. Trenchless insertion of non-structural liners is used to arrest internal corrosion and isolate the gas from the internal wall surface; these liners are mostly cured in place and used in preventing gas leakage through pinholes in the corroded sections. Composite wraps are used as structural components to substitute for loss of pipe strength due to pipe metal loss and gouge damage. This repair may also apply to other surface damages such as cracks and pinhole leaks when the application is proven through reliable testing and analysis.

The assessment found that existing rehabilitation technology for gas distribution is established for internal corrosion control and for localized mechanical damage repair, while cement mortar lining, proven in liquid distribution, has seen limited adoption and durability in gas systems. Newer options reviewed included a spray applied thick epoxy lining developed under a federally funded program and several fiber reinforced spoolable composite pipe products, some with embedded condition monitoring.

This project is complete. A Final Report was issued in June 2025.

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Gas Service Regulator Vent Field Study

Researchers will quantify natural gas volumes emitted from the vent of residential, commercial, and industrial gas regulators and compare relief valve technologies in order to inform utilities efforts to reduce methane emissions.

Project Description

Traditional gas service regulators are designed with an internal relief valve (IRV), a device that helps maintain pressure by venting small quantities of gas when a pressure increase is detected. Several of the gas service regulators in service currently include IRV and have an emission footprint. Newer dual-diaphragm, vent-limited regulators claim to address this issue by emitting less.

The goal of this project is to quantify natural gas volumes emitted from the vent of residential, commercial, and industrial gas regulators and compare emission rates of traditional internal relief valves (IRVs) and dual stage vent limited regulators during normal operation. The team will track and characterize emission events for different gas demand cases, such as high population density buildings and commercial/industrial utilization.

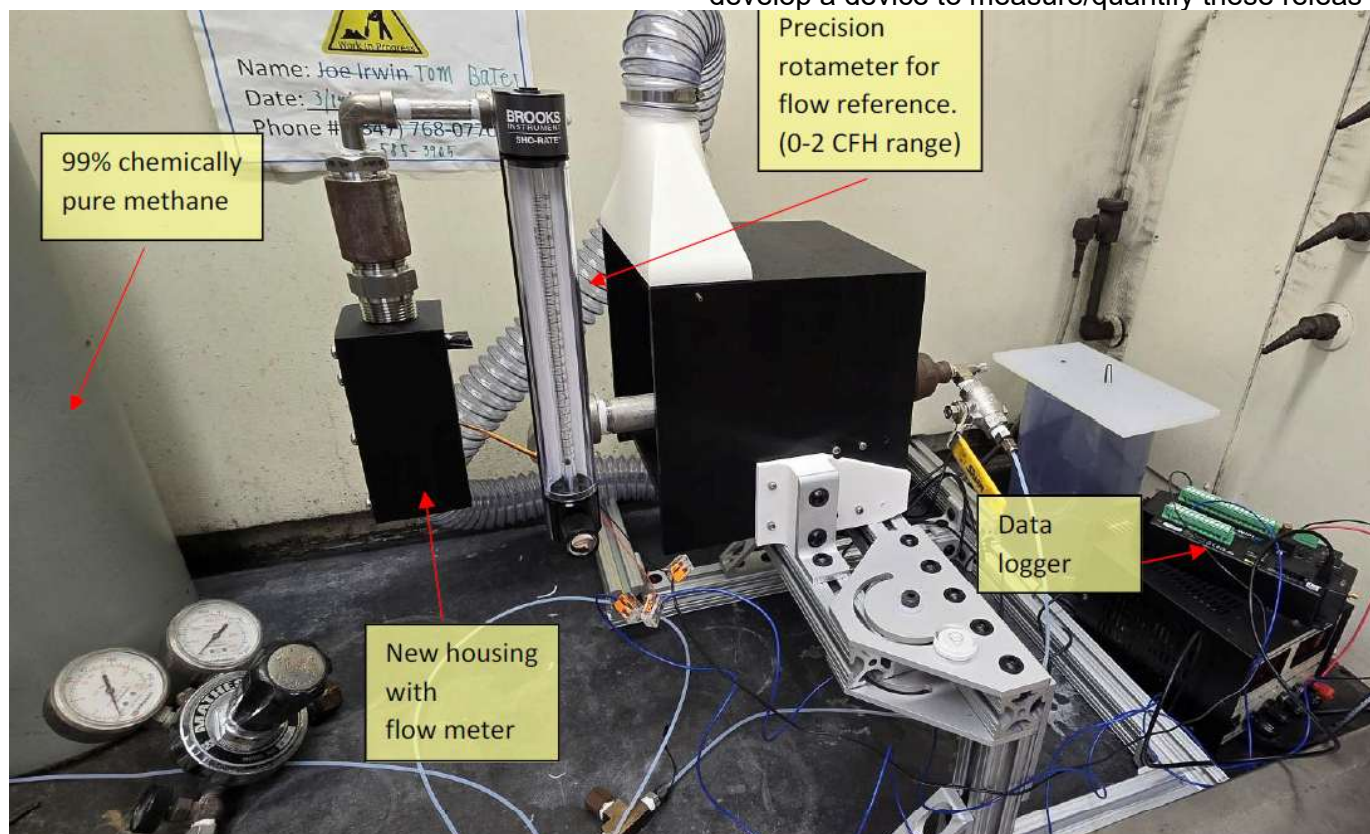
This Phase 1 effort will focus on the development of an instrument that can be deployed to quantify the number of times the equipment vents to atmosphere and the volume of gas released each time.

Deliverables

The team will deliver a functional prototype of the sensor assembly for use with residential gas service regulators to measure releases and submit a final report of these findings.

Benefits

Limited data is available on operational releases from regulator and relief vents as a result of challenges in predicting the frequency of venting events, along with the volume emitted each time venting occurs. This project will provide a better understanding of the volume of gas released and develop a device to measure/quantify these releases.



Sensor assembly and flow test setup

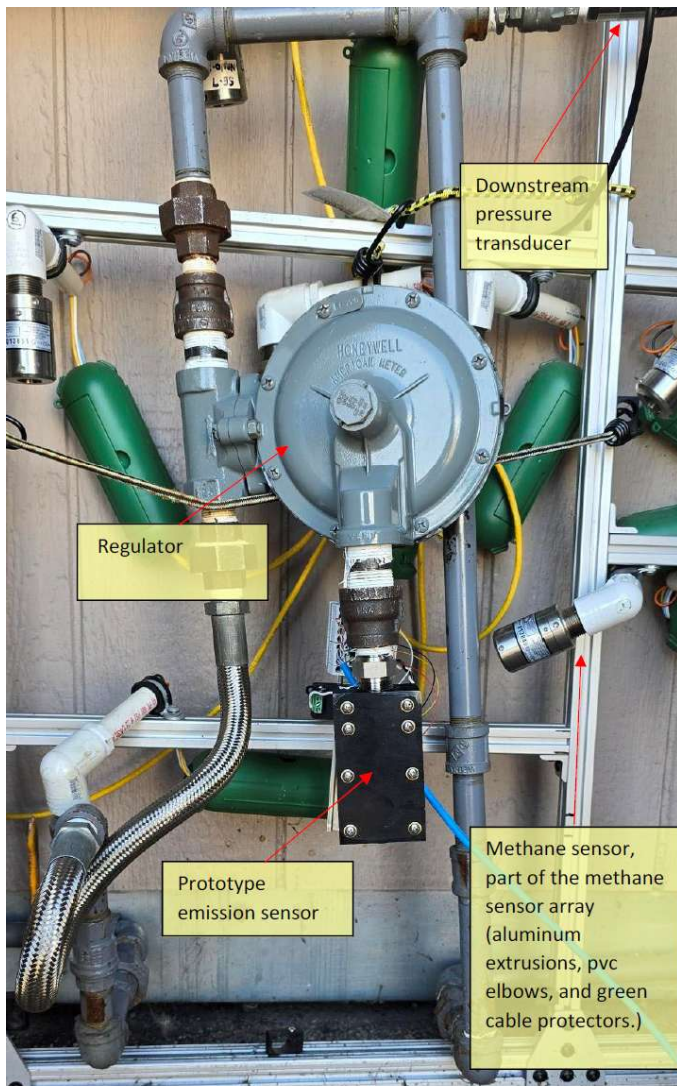


Image showing the outdoor testing setup

es. The device to be developed in this initial phase will allow pipeline operators/utilities to establish a baseline of the volume of gas being released from these assets. The information developed can be used to capture the decrease in the volume of gas released as these assets are replaced over time.

Technical Concept & Approach

Specific tasks in this project include:

Sensor Selection and Prototype Design

Develop system requirements and functional design, select the sensors, determine the battery power requirements, develop the mechanical design

Development of Prototype and Internal Testing

Prototype the housing, develop data logging and logic, develop the embedded firmware, develop the modifications needed for use with higher capacity regulators, Test the IRV and vent limited regulators with both air and live gas in the laboratory.

Results/Status

The team successfully designed a sensor prototype to effectively measure natural gas emissions from residential gas regulators. Multiple sensor devices were evaluated to ensure only the correct technology was selected. The team chose a flow meter and methane sensor for the main sensors.

After building a sensor housing, the sensor prototype underwent flow testing with air and gas to observe its capability to capture the small releases of gas from a pressure regulator, also known as "burps." A successful sensor prototype required a data sampling rate fast enough to capture these quick emission events. The team also designed safety features into the sensor prototype to ensure the outlet pressure of the regulator did not exceed the threshold during a critical failure in the regulator such as a lever disconnect. These requirements are described in ANSI B109.4 2021, Self-Operated Diaphragm-Type Natural Gas Service Regulators.

After months of design and testing, the resulting prototype is a working sensor instrument that can record venting events and methane volumes emitted over a one-month period with the current battery, sensor, and data logger configuration. This duration was calculated as a "worst case," where the data logger is constantly logging emission events. The sensor can quantify the activity (number of times the equipment emits), volume (amount of gas emitted each time), and the concentration of methane present in the emission.

The next step in achieving the overall goals for this device would be to improve the design based on the following criteria: reduce the unit cost; for example, changing to a different data logger would reduce the cost dramatically; improve the design to incorporate more intrinsic safety features; perform compliance testing to ensure intrinsic safety; produce a sample set of these devices for deployment; and deploy the devices on utility infrastructure as part of a pilot field study. The intention would be to both start the campaign of regulator emission quantification and to continue improving the device.

This project is complete. A Final Report was issued in March 2025.

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Field Pilot Deployment of Gas Regulator Vent Emission Sensor

The team will advance a service regulator vent emission sensor from prototype to field deployable tool, manufacturing and deploying units at host utilities to quantify emissions from distribution gas regulator vents. The resulting data will enable operators to establish emissions baselines, improve reporting accuracy, and prioritize regulator replacements.

Project Description

This project will support the manufacturing and field deployment of emissions sensors to quantify emissions from distribution gas regulator vents. This will help identify and prioritize regulator replacements.

Traditional gas service regulators are designed with an internal relief valve (IRV) that vents out small quantities of gas whenever there is a significant downstream pressure spike, such as a sudden stop in downstream gas flow. These small emissions, commonly called “burps,” are not generally hazardous but contribute to the amount of methane emitted to the atmosphere. The IRV is also designed to protect against overpressurization in piping downstream of the gas meter. For example, if the regulator diaphragm tears, the IRV is de-

signed to vent this gas to atmosphere to protect the customer piping. When looking at the total volume of IRV regulators still in service, the total emission footprint caused by these “burps” or “failure events” becomes increasingly significant.

In Phase 1 (project 7.23.a), GTI Energy designed and developed a service regulator vent sensor device that can be installed on existing in service regulators, capable of recording venting events and methane volumes emitted over a period of approximately one month. This Phase 2 project will further develop the functional prototype into a field deployable tool that operators can use in their emission identification and tracking campaign.

Deliverables

Deliverables for this project include an approved prototype requirements list, a modified sensor design compliant with utility standards, compliance testing results, up to 13 field-deployable gas regulator vent emission sensors, and an initial field data review and troubleshooting report.

Benefits

The regulator vent sensor will allow pipeline operators/utilities to quantify a baseline of current emissions from these assets for integrity management and emissions reporting. The device will also support more efficient regulator replacement by identifying faulty equipment. Gas service regulators and relief valves used in natural gas infrastructure may



Field inspection of gas service equipment using leak detection technology

account for a substantial amount of emissions, and



Prototype testing setup for evaluating service regulator and meter performance

measured emissions from in service regulators will allow operators to more accurately report rates and possibly identify the more emission-prone service regulators in their systems.

Technical Concept & Approach

In Phase 1, a service regulator vent sensor device was designed and developed that can be installed on existing in service regulators. The device can record venting events and methane volumes emitted over a period of approximately one month. This project will further develop the functional prototype into a field deployable tool that operators can use in their emission identification and tracking campaign.

The work will include implementation of required modifications and testing of the improved prototype. Up to 13 sensors will be manufactured and set up for deployment. The team will set up and troubleshoot sensors in the field and provide support during evaluation. Initial field data will be reviewed and troubleshoot accordingly.

Results/Status

The project kickoff call was held on September 9, 2025, and an electrical subcontractor was identified to improve several features of the sensor prototype device. The project team developed the scope of work and began negotiations with the subcontractor for the sensor upgrades. The SOW is currently being finalized.

Next steps include the subcontractor beginning work on the data logger hardware design and GTI Energy refining the housing design and overpressure safety mechanism.

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Advanced/Outside Natural Gas Leak Detector

Researchers will develop an Advanced/Outside Natural Gas Leak Detector (ONGD) that can discover a leak sooner than conventional means reducing risks to buildings and their occupants.

Project Description

OTD has performed extensive work on the development and testing of Residential Methane Detectors (RMD or NGD) that can provide a warning to both the customer and the gas utility of a potential leak. Early detection can play a pivotal role in preventing leaks from growing/migrating, and potentially creating a hazardous environment or resulting in an incident.

The goal of this project is to develop an Advanced/Outside Natural Gas Leak Detector (ONGD) that can discover a leak before being found through traditional means, such as by an odor call or scheduled leak survey, reducing risk and improving safety. This project will work with industry subject matter experts and manufacturers on the development of an Advanced ONGD prototype that can be attached to the Meter Set Assembly (MSA) piping. The prototype device will be installed at a pipe farm and tested during various weather conditions and various concentrations of natural gas.

Deliverables

The deliverables of this project will include a table

outlining the proposed advanced ONGD specifications, a project test plan outlining how the ONGD will be tested, a functioning prototype for testing purposes, and a final report documenting project activities, prototype testing results, conclusions, and recommendations.

Benefits

Outside natural gas leaks can migrate underground and have the potential to find a path into a building or a confined space leading to a hazardous condition. Quicker notification of an outside leak allows more time for a gas utility employee/contractor to be dispatched to perform a leak investigation and prevent any serious escalation of the gas into a building or a confined space.

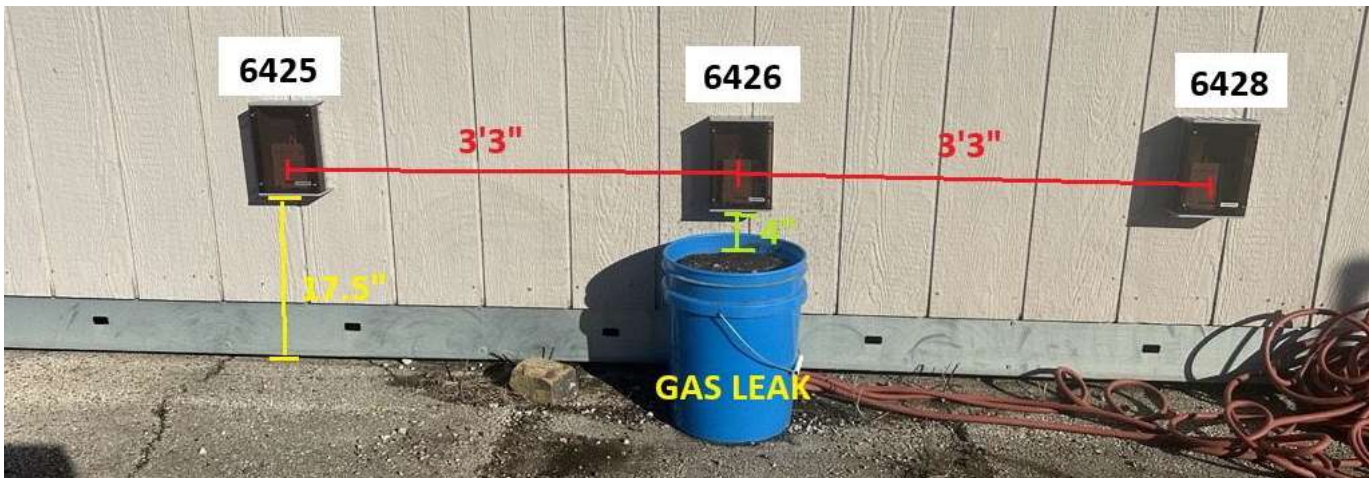
The ability to discover and be notified of an outside gas leak using a stationary outside methane sensor will provide quicker detectability as compared to the current processes of leak notification. Early detection is key for safety, improved effectiveness and reduced costs associated with an emergency.

Manufacturers and vendors in the leak detection market offer multiple types of equipment and solutions to perform the federal requirement of leak survey over gas facilities. Since natural gas incidents still occur after these leak surveys are performed, an additional layer of leak detection that can provide continuous (24 hour) surveillance to detect and notify of leaks will further improve safety.

There is a demand and recent technology opportunity to develop an Advanced ONGD since there have been current advancements in methane sensors that have focused on low-power



Flow rate of the leak.



Simulated Leak Outside Setup

(for long life battery use), high accuracy (no false positives), improved detectability (for higher ppm) and improved durability to environment conditions (allow for long-life in an outside environment). Many of the newer methane sensors on the market are significantly more advanced than previous sensors and this offers an opportunity to develop a product that will make the natural gas industry safer.

Technical Concept & Approach

The project team will work with industry subject matter experts to define the prototype criteria and specifications. Additionally, a market study will be performed to identify each advanced ONGD component with a focus on the methane sensor. The results will be summarized into a test plan that will be approved by stakeholders.

The project team will develop blueprint drawings, purchase components and assemble a prototype. The prototype will be tested in accordance with the approved test plan.

Results/Status

The ONGD prototype, designed for installation on Meter Set Assembly (MSA) piping, was tested under various environmental conditions, including wind, humidity, and freezing temperatures. The prototype detectors effectively detected methane, hydrogen, propane, and methane-hydrogen blends with high sensitivity, even at concentrations as low as 20 ppm. Despite these environmental challenges, the sensors provided reliable readings.

Several areas for improvement were identified. Narrowing the spectrum of detectable gases could enhance efficiency and reliability, particularly by

addressing the prolonged recovery time observed after propane exposure, which required several hours for the detector to return to baseline levels. Testing identified that propane contamination should be considered as it can obscure readings of other gases like hydrogen and methane, potentially affecting accuracy in environments where multiple gases coexist. Mitigating this interference is essential to maintaining precise and reliable detection capabilities.

Environmental challenges, such as wind dispersion, were found to affect detection reliability by dispersing gas concentrations. Incorporating multiple sensors would improve the device's ability to identify leaks in such conditions, increasing its overall sensitivity and accuracy.

Battery performance was not the primary focus of this study, but testing involved an increased up-link transmission frequency, every minute instead of the typical hourly interval, to capture near real-time data. This resulted in battery depletion after approximately two months. To optimize long term performance, dedicated battery life testing is recommended to determine the most efficient balance between transmission frequency and battery longevity.

In conclusion, the prototype demonstrated potential as a tool for early natural gas leak detection. The project team recommends piloting the leak detection device in the field. This project is complete. A Final Report was issued in February 2025.

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Advancing Hydrogen Leak Detection and Quantification Technologies Compatible with Hydrogen Blends (US DOT PHMSA)

Researchers will evaluate the impact of hydrogen blending on natural gas leak detection equipment and sensing technologies, and provide guidance on work practice changes to ensure operators can safely and effectively survey pipeline assets as hydrogen is introduced into the gas distribution system.

Project Description

The purpose of this project is to advance leak detection as hydrogen is introduced into natural gas infrastructure. The project team will evaluate various leak detection equipment currently being used by natural gas pipeline operators and provide guidance and analysis on how hydrogen impacts their use and protocols.

Deliverables

The deliverables of this project include a literature review, a leak detection system validation test plan, test results for laboratory and field-based tests, newly developed technologies or methodologies to detect leaks from pipeline infrastructure as hydrogen is added to the natural gas, and a final report.

Benefits

The findings of this project are crucial for advancing understanding of hydrogen and natural gas/hydrogen blend leaks, ensuring that any leaks can be detected quickly and efficiently, reducing potential safety impacts caused by undetected leaks, and minimizing misinterpreted leak detection results causing an underestimation of the size and potential safety hazard of a leak.

Technical Concept & Approach

Specific tasks in this project include:

Understand Leak Dynamics and Identify Testing Scenarios

This task includes a literature review of the work done on the dynamics of a hydrogen/methane mixture when leaving a pipeline and the evolution of the subsequent plume; a survey of real use cases within the industry and a characterization of these scenarios (i.e., amount of hydrogen present). The project team also will provide technical test specifications to guide technology evaluation/development and identify methods for real life testing.

Evaluation Testing of Common Leak Detectors

The project team will evaluate the efficacy of commonly used gas detection technologies within mixtures containing varying amounts of hydrogen; acquire commonly used leak search tools within the industry and survey their pertinent specifications for comparison; evaluate in a laboratory setting the efficacy of such tools given varying amounts of hydrogen injection; and test the efficacy of such tools in the field given varying amounts of hydrogen injection.

Explore and Evaluate the Technology Readiness Level

The project team will develop an overview of potential detection paradigms to provide information regarding what sensors are required; conduct a literature review of sensing technologies available in the market and within academia; select promising technologies and perform benchtop testing; and engage with industry to field test these sensing technologies

Controlled Field-Based Evaluation Testing

The project team will formulate recommendations with regards to changes to work practices to best use leak search equipment; formulate a plan with regards to potential obsolescence of existing technology and equipment; and identify and advance the next generation of sensors required for leak search equipment.

Statistical/Data Analysis

For this task the team will acquire statistically significant data. They will conduct Analysis of Variance (ANOVA), which will be used to verify the representativeness of the datasets, especially across operators and sites.

Results/Status

A literature review was completed to understand the impact of hydrogen on leak dynamics, focus-

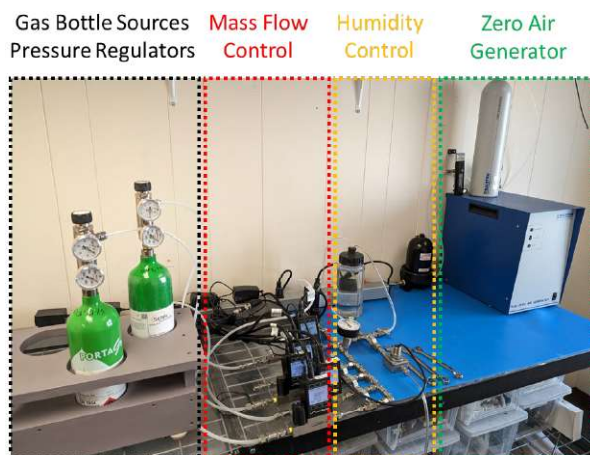
ing on the potential stratification of hydrogen from other gases in a variety of flow situations and the impact on low pressure systems. No preferential leakage (stratification) of hydrogen/natural gas blends was found in studies of low-pressure systems (<55 psig). Partial stratification of hydrogen and natural gas was only observed at the initial leak point of underground leaks and in the pipeline when flow was stagnant; for underground leaks, the mixture would return to normal composition as the leak migrated to ground level, and in pipelines, the gas mixture would become well-mixed again as flow resumed.

The project team evaluated 14 commercially available leak survey and investigation instruments along with 22 standard and novel sensors to understand the impact of hydrogen on detection performance and to determine if significant technological gaps are found. Survey instruments were tested in both laboratory and field settings while sensors were only tested in the laboratory. All instruments and sensors were tested with pure natural gas or methane and with gas/hydrogen blends up to 80%/20% natural gas or methane to hydrogen. Instruments and sensors configured to measure toxic gases were also evaluated to observe the effects of hydrogen on carbon monoxide and hydrogen sulfide sensors. Lastly, the impact of hydrogen on oxygen sensors was investigated in the laboratory.

Three field trials were completed, each at a distribution training facility piloting hydrogen-blended natural gas or methane. Trials included simulating underground and aboveground leaks on pipeline assets and simulating industry walking surveys to analyze detection performance. Leak rates ranged from less than one standard cubic foot per hour (scfh) to over 50 scfh. Most tests (82%) focused on lower flow leaks, less than 5 scfh, as these are relatively harder to detect.

While the explosive risk is slightly higher and small leaks become slightly more difficult to detect, there is no apparent significant difference in the overall risk of conducting leak surveys with hydrogen blends up to 20%. Higher surface expression leaks remain relatively detectable as the hydrogen blend increases. Smaller leaks that are marginally detectable may become harder to detect due to the reduction of the methane content.

Field testing results showed that the introduction of hydrogen did not have a significant impact on the ability of current commercial devices to detect leaks on belowground, aboveground, and appli-



ance assets. The true positive detection rate for pumped instruments detecting leaks with blends of 10%, 15%, and 20% hydrogen content ranged from 85-95% compared with 84% when no hydrogen was blended into the natural gas stream. Laser instruments demonstrated a linear decrease in positive detection rate as hydrogen content increased: 47% true positive rate for natural gas-only, compared to 43%, 38%, and 34% for hydrogen blends of 10%, 15%, and 20%, respectively.

For flammable gas detection, the impact of hydrogen is heavily dependent on the specific sensor technology. Catalytic bead sensors and Molecular Property Sensors are influenced the least and require minimal to no compensation for hydrogen blends. Standard thermal conductivity sensors will over-report gas concentration proportional to the hydrogen. Metal Oxide Semiconductor (MOS) sensors will see a substantial increase in apparent methane LEL readings for increasing amounts of hydrogen. Optical absorption devices are blind to hydrogen and will under-report flammable gas by the percentage of hydrogen in the blend.

For toxic gas detection of hydrogen sulfide or carbon monoxide, the interference of hydrogen is severe. Carbon monoxide sensor recovery and stability is negatively impacted by hydrogen exposure at levels greater than 10,000 ppm; below 10,000 ppm no lasting damage to the sensor is expected. For devices employing carbon monoxide and hydrogen sulfide sensors, it is recommended to avoid exposure to hydrogen concentrations exceeding 5% volume for more than 30 seconds.

This project is complete. A Final Report was issued in September 2025.

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GeoTeknica Optical Laser Gas Imager Monitor

This project will provide technical guidance and evaluation to support the development of a high sensitivity optical gas imager for continuous monitoring applications. Fixed continuous monitoring can detect leaks on critical infrastructure as they occur and may reduce risk and emissions.

Project Description

GeoTeknica is in the early stage of technological development of a high sensitivity optical gas imager (OGI) for use in continuous monitoring applications. This project will assist with technical guidance and evaluation in development of GeoTeknica's gas imaging technology.

GeoTeknica has invented a new generation of active laser scanning methane imager with the advanced detection capabilities of leading LiDAR systems. GeoTeknica aims to commercialize this technology at a cost advantage that will permit operators to install multiple units at a facility for comprehensive detection coverage. Deployed strategically, this could enable detection without occluded regions, as well as generation of 3D emissions profile by simultaneous detection of leaks from multiple angles.

Software analytical tools are designed to process data and generate a near-real-time estimation of methane emissions of a precision currently unattainable with existing technologies. Target appli-

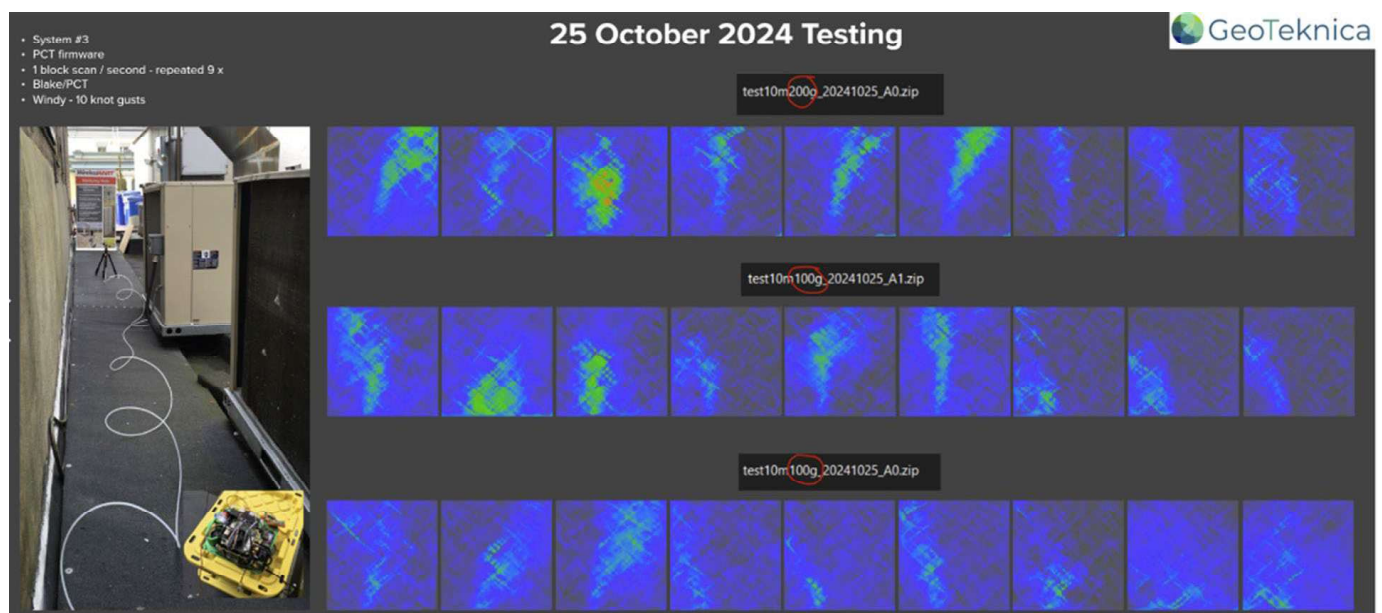
cations of this solution include upstream facilities, midstream operations, and high-consequence utility infrastructure.

Deliverables

This project will provide analysis and recommendations on advancing the development of a high-performance optical gas imager for fixed monitoring applications.

Benefits

Fixed continuous monitoring can detect leaks on critical infrastructure as they occur, enabling faster response than periodic inspections and helping may help reduce risk and emissions. A more sensitive continuous monitoring instrument could detect, locate, and quantify smaller leaks more quickly, supporting earlier intervention and improved emissions management. Potential initial applications include high-consequence transmission lines and M&R stations.



Initial methane plume imaging achieved. Leak detection and imaging of 100g/h and 200g/h flow rates.

Technical Concept & Approach

This project will seek to provide technical input in development of an alpha prototype and evaluate detection performance. Work will be divided into the following tasks:

Preliminary Design Review

Confer with GeoTeknica as prototype development progresses and provide technical guidance.

Prototype (Laboratory) Testing

Test the prototype instrument in the laboratory. Initial tests will focus on controlled leak rates under indoor controlled conditions to better understand detection lower limits. Outdoor testing will focus on establishing detection limits with uncontrolled test conditions such as background, above and below ground.

Gas Town (Field) Testing

Test the prototype in field situations. This will focus on additional data gathering to support the analysis of detection limits. Using an OTD member training facility, data will be collected on the various leak locations and flow rates over a course of a week.

Results/Status

GTI Energy initiated this project with GeoTeknica to support development of a laser-based gas imaging and detection system for fixed monitoring applications. The work focused on requirements for metering and regulation stations and other high-consequence infrastructure. GTI Energy provided technical input through design reviews, evaluation guidance, and laboratory testing support.

GeoTeknica developed and demonstrated an alpha prototype that detected and imaged leaks under controlled test conditions. The prototype included a wide field of view scanned without mechanical movement, real-time field-of-view adjustment to search for and locate leak sources, sensitivity reported at 10 ppm-m, detection of leaks as low as 1 scfh, leak-rate quantification under high wind conditions, and a target cost below other laser-based continuous monitoring instruments.



Outdoor testing using simulated underground leak.

Testing showed that the prototype could detect methane leak rates comparable to other hand-held leak survey instruments and below the PHMSA ALDP minimum sensitivity threshold for monitoring. Gas plume imaging was observed across multiple leak flow and wind conditions. The dynamic field of view allowed the system to search a larger area, identify a plume, narrow the field of view to locate the source, and further focus on the source for additional measurements. Leak flow-rate estimation had not been implemented at the time of testing and was not evaluated.

The project completed key design and prototype testing activities needed to inform further development and potential field testing under more realistic operating conditions.

This project is complete. A Final Report was issued in June 2025.

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Reliable Affordable Infrastructure for Secure Energy (RAISE)

RAISE equips stakeholders with a holistic understanding of the complexity and value of existing natural gas infrastructure systems, and provides actionable recommendations on the research, technology development, partnerships and investments required to upgrade and evolve the country's gas infrastructure to advance safer and more reliable energy systems.

Project Description

The U.S. gas infrastructure network consists of thousands of miles of connected pipelines and storage facilities that help provide reliable and affordable energy in today's energy systems. Pipeline companies also delivered 75% of the natural gas used to generate electric power in the U.S. in 2023. With electricity demand continuing to increase significantly, understanding how to maintain, upgrade and modernize this extensive infrastructure network will be an important lever in energy system transition. Additionally, natural gas infrastructure will be critical to moving increasingly decarbonized natural gas and other gases, such as renewable natural gas, hydrogen, and carbon dioxide (CO₂).

Reliable Affordable Infrastructure for Security Energy (RAISE) focuses on defining and capitalizing on the opportunity associated with upgrading existing natural gas infrastructure to accelerate deployment of emerging low-carbon fuels and decarbonization solutions while saving costs, minimizing environmental impact, and stimulating job creation and economic growth. RAISE is a multi-year research effort that will give stakeholders better data, actionable insights, and opportunities for increased collaboration while operating from the foundation that future energy systems must be reliable, safe, resilient, sustainable, and affordable.

Deliverables

The program deliverables are published regional case studies that assess the role of current and future gas infrastructure by midcentury, published short-form research papers on industry relevant topics that educate stakeholders on the complexity and considerations of gas infrastructure in integrated energy systems, and a series of educational workshops conducted with State Public Utility Commission (PUC) stakeholders.

Benefits

RAISE aims to build off existing studies and research, focusing on addressing how integrated energy systems will evolve and how stakeholders should plan and invest in gas infrastructure throughout the energy transition. RAISE is also an opportunity to build dialogue and collaboration across stakeholders including researchers, investors, operators, asset owners, and local communities.

Technical Concept & Approach

RAISE's program is divided into three key priorities and has an interactive web portal that houses up-to-date technological and regulatory developments, RAISE-related research, and webinars.

Understand the value of gas and related energy infrastructure

In 2025, the team completed the Gulf Coast regional case study and integrated emerging research on resilience and reliability to better understand the value of natural gas infrastructure in both current and future energy systems. Research findings were shared with stakeholders to help evaluate how existing gas infrastructure can support decarbonization objectives while maintaining system reliability and affordability.

The team also published two reports providing insights on underground gas storage in the Gulf Coast and East Coast. These reports examined underground gas storage's role in stabilizing prices, supporting grid resilience, and its potential or repurposing to meet decarbonization goals.

Support Education of External Stakeholders

In 2025, the program finalized content development for the utility commission workshops, with workshop topics covering U.S. Gas and Infrastructure Systems, Innovation in Infrastructure Maintenance & Monitoring, Emissions Life Cycle Analysis, and RNG/Hydrogen Integration.

Strengthening collaborations and partnerships

In 2025, the team published the Gulf Coast regional case study with KeyLogic, a highly specialized energy systems modelling partner, and continued to work closely with partner organizations such as NARUC, and other regional gas association groups. RAISE has also convened a regional Gulf Coast external advisory group comprised of partners from ICF, RMI, BEG's Center for Energy Economics, and the Texas Hydrogen Alliance.

Results/Status

The Gulf Coast Case Study was completed in 2025. The case study analyzed 16 low-carbon fuel pathways (hydrogen, RNG, and SNG), using an integrated analysis framework combining OL-NEMS modeling, Techno-Economic Analysis (TEA), Life Cycle Assessment (LCA), and Cost-Benefit Analysis (CBA). The case study evaluated state specific opportunities (Arkansas, Louisiana, New Mexico, Mississippi, Alabama, and Texas), to expand fuel production suited for delivery via existing gas infrastructure. Technology pathways evaluated include hydrogen via Proton Exchange Membrane (PEM) Electrolysis, Steam and Autothermal Methane Reforming with Carbon Capture & Storage, Plasma Pyrolysis, Anaerobic Digestion (RNG) and Methanation (SNG).

Key findings indicate the Gulf Coast is well positioned to use existing gas infrastructure to support lower-carbon fuels such as hydrogen, renewable natural gas, and synthetic natural gas. The study found that hydrogen appears to be one of the more practical near-term options for the region, especially where existing infrastructure can be reused. Broader deployment would still depend on supportive policies, market conditions, and continued investment in infrastructure modernization.

Two additional reports examining underground gas storage (UGS) in the Gulf Coast and East Coast were published in 2025. The reports found that UGS supports reliable energy delivery by balancing seasonal demand, stabilizing prices, and strengthening resilience during extreme weather and supply disruptions. The Gulf Coast benefits from high-deliverability salt caverns, while East Coast storage is concentrated in five states and support-



ed by critical interstate pipelines.

The project team also initiated work on the East Coast Case Study in 2025. The case study report was issued in January 2026. The study found that repurposing existing pipelines can be significantly more cost-effective than constructing new hydrogen pipelines. Modeled results show that hydrogen and RNG pathways offer promising emissions-reduction potential, with hydrogen estimated at 3.12 kg CO₂e/kg H₂ and RNG estimated at 5.70 kg CO₂e/kg RNG, while the assessed SNG pathways did not demonstrate emissions benefits. The case study also highlights the East Coast's strong resource and infrastructure position, including natural gas reserves and storage in Pennsylvania and West Virginia, regional renewable energy resources, biomass and waste availability, and existing pipeline and storage assets that could enable future fuel deployment with targeted modernization. Emerging fuels remain higher-cost than conventional natural gas under current conditions. Cost parity generally requires incentives in the range of \$250-\$550 per ton of CO₂ avoided, varying by state and pathway. Overall, the findings suggest that the East Coast is well positioned to advance emerging fuels through strategic siting, infrastructure upgrades, supportive policy, and workforce development, while maintaining reliability and reducing carbon intensity.

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Satellite Methane Detection for Distribution Applications

Researchers will evaluate emerging software solutions for satellite based detection of methane leaks to determine whether they could support leak detection across distribution systems. If effective, satellite monitoring could let LDCs survey large areas at a regular cadence and quickly prioritize potentially hazardous leaks, improving how they maintain their pipeline networks.

Project Description

This project seeks to evaluate newer satellite based methane detection products that claim significantly more sensitive detection of methane emissions than those previously studied. The study will focus on LDC applications for leak detection, localization, and quantification.

Satellite based methane detection has so far been effective mainly in the upstream oil and natural gas segments, such as production and processing. Prior studies indicate that satellite detection thresholds remain well above distribution level leak rates, so the applicability to distribution appears limited.

In recent years, numerous competitors have entered the market with claims about their products' effectiveness, some asserting the ability to infer leaks at distribution level rates (below 1 kg per hour) using AI and advanced geospatial analytics.

Deliverables

Deliverables for this project will include a literature review, a test matrix, test results, and a final report.

Benefits

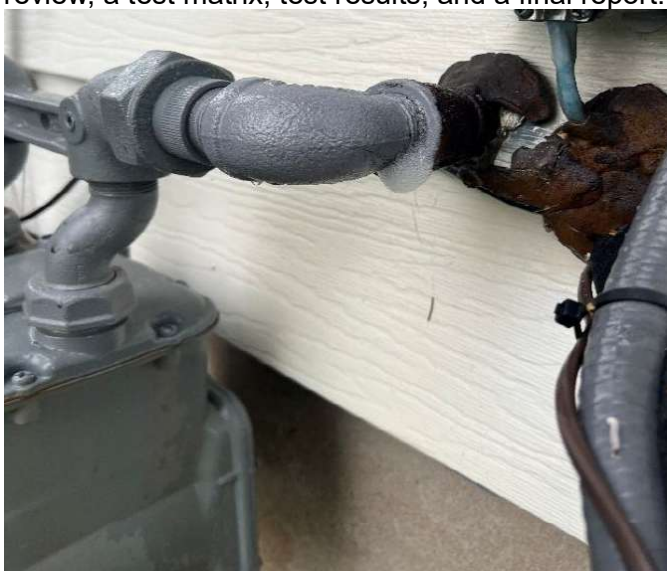
By evaluating the technical performance and cost effectiveness of current satellite based products, this project will give LDCs a clearer basis for deciding whether the technology is a useful tool for detecting leaks on their distribution systems. If effective, satellite monitoring could improve how operators survey and maintain their pipelines and help prioritize potentially hazardous leaks, benefiting the safety of customers and the public, though the technology may require further development for this use case.

Technical Concept & Approach

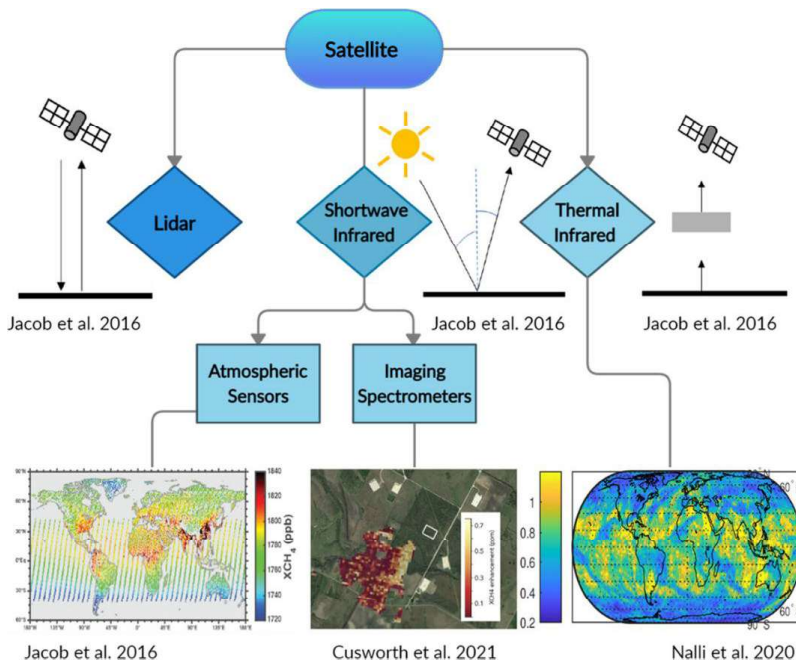
Specific tasks in this project include:

Literature Review and Academic Feedback

Review published work on satellite evaluation for methane detection and survey academic and technical experts on the current state of the technology, identifying the crucial variables in satellite based detection and what needs to be better understood for distribution applications.



Examples of leaks found on survey follow ups: a fizz leak on the meter, post-meter(left) and a belowground leak on service line (right).



Satellite Technology Diagram

Field Testing Logistics and Test Matrix Design

Work with sponsor companies to understand their concerns and experience with satellite leak detection and identify test opportunities, then develop a plan for field testing and ground truthing of satellite data, along with a statistical approach for the large volume of data to be collected.

Go/No Go

Based on the information gathered early in the project and on sponsor feedback, determine whether field deployment is warranted and coordinate with sponsors around upcoming satellite capture events.

Field Deployment

Conduct two targeted field deployments to evaluate the technology, including implementation of the test matrix and verification of leak rate on a subset of leaks, with appropriate follow-up surveys.

Data Analysis

Evaluate satellite capture data for true and false detection results, examine whether the leak source is correctly identified (for example, distinguishing a gas facility from a natural or industrial methane source), and account for conditions at the time of survey.

Results/Status

This project investigated whether satellite based methane detection is a useful leak detection tool for local distribution companies (LDCs). Rapid-SUMMARY REPORT

ly developed over the last decade, the technology can survey large areas at a regular cadence. The project team evaluated it through a literature and market review and through field testing on LDC infrastructure.

The review found many satellite methane monitoring providers, but only one currently markets a detection service to distribution operators; that service became the focus of the evaluation, informed by interviews with four OTD member sponsors who had run field demonstrations with it. The literature and interviews indicated that satellite based leak monitoring still requires additional development to support directed leak surveys on LDC systems.

Partnering with one utility sponsor, the team ran six satellite flyovers and sent field crews to investigate 84 satellite-indicated locations and 42 control locations (addresses with no indication within 500 feet), using industry standard tools and keeping crews blind to which was which. Crews were about as likely to find leaks at control locations (~30%) as at satellite-indicated ones (~34%), and prioritizing indications by flow rate or by repeat detection across flyovers did not improve the find rate. Sharing known leak locations beforehand modestly raised the find rate for existing leaks but not for discovering new ones.

Overall, the results do not demonstrate an advantage to using satellite monitoring for detecting methane emissions on distribution infrastructure; find rates across the study ranged from 28% to 38% regardless of prioritization. Because each capture produces a large number of indications (an average of 236 per scan), a clear prioritization strategy would be essential for practical use. The team identified several areas for further work, all aimed at better characterizing the technology for distribution applications: controlled release testing to establish detection limits by flow rate, tighter timing between satellite survey and ground follow-up to confirm leak attribution, and a larger review against known leak inventories.

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Technology Roadmap for Compressor Station Methane Emissions and Mitigation Scenarios

Researchers will develop a technology roadmap of design and equipment considerations for new and existing natural gas compressor station facilities to guide methane emission mitigation efforts, helping operators navigate potential solutions and make informed decisions balancing cost, reduction efficiency, and ease of implementation.

Project Description

The project team will develop a technology roadmap of the design and equipment considerations that can be implemented on new and existing natural gas compressor station facilities to drive methane emission mitigation/reduction efforts. The effort will be divided into 3 Focus Areas: gathering and distillation of existing information from on-going development efforts, quantification of potential methane emission reductions through the implementation of new technologies at compressor station facilities, and technology roadmap development.

Deliverables

Deliverables for this project include a comprehensive literature review of technology solutions for detecting, monitoring, and mitigating methane emissions from compressor facilities, a spreadsheet-based model for evaluating potential emission reductions via various pathways, and a multi-layered technology roadmap for compressor facility operators. The findings and recommendations are detailed in a final report.

Benefits

A major challenge associated with U.S. energy systems is protecting people and the environment by advancing the safe transportation of energy and hazardous materials through system infrastructure. In the natural gas supply chain, a critical aspect of addressing that challenge is detecting, quantifying, and mitigating methane emissions.

Minimizing methane releases from the entire natural gas supply chain is crucial to reducing impacts to the environment, climate, and safety. Methane is the primary component of natural gas and a potent greenhouse gas (GHG). It is crucial to understand the annual atmospheric methane emissions from the natural gas supply chain so that targeted methods can be deployed across segments to reduce emissions.

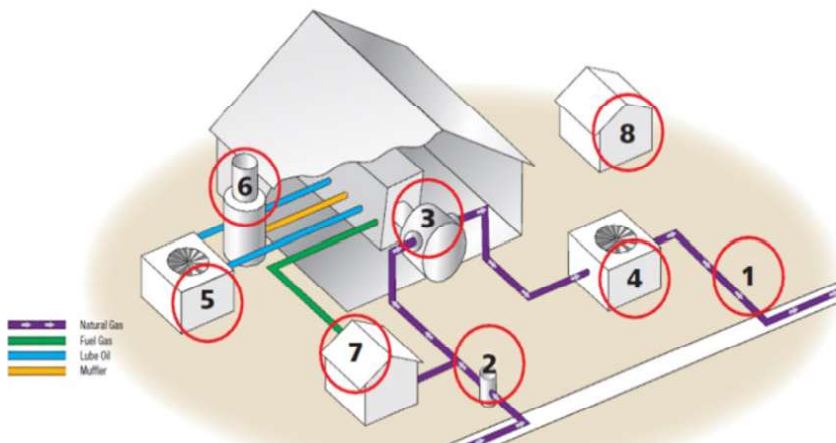
Compression of the gas is the largest emission contributor within the gas transmission and distribution sector. Compressors are used along the entire natural gas supply chain to move or store gas across the country. The largest source within compressor stations is from reciprocating engines followed by station venting, engine exhaust, and general fugitive emissions.

Technical Concept & Approach

The project will be divided into three tasks to achieve the goals laid out for the project. The project team will assemble existing peer-reviewed and grey literature on technology solutions that can be used to detect, monitor, and mitigate methane emissions from compressor facilities. The initial literature review will focus on standard operational designs of compressor facilities and problem areas that most enable fugitive emissions. The team will explore available site-level and asset-level emissions estimates and designate relative high emission areas and equipment to prioritize mitigation methods. The second literature review will survey investigation and monitoring technologies to provide operational controls to emission sources. Information gathered from this review will form the basis of the technology roadmap, leading to an ALDP based methodology and procedures framework for compressor stations.

Following the literature review, the project team will use the information gathered on compressor station design to review quantified emissions data. For this task, the team will review strategies for mitigation at multiple levels of operations: equipment, process, and monitoring. Combining equipment repair and replacement strategies with an ALDP, a spreadsheet-based model will be created to evaluate how to estimate potential emission reductions via various pathways.

The project team will organize the information collected in previous tasks into a multi-layered technology roadmap that can be used by compressor



1. Station Yard Piping / Common Components
2. Filter Separators / Scrubbers
3. Compressor Units
4. Gas Cooling Systems
5. Lube Oil System
6. Mufflers (Blowdown Silencers)
7. Fuel Gas System
8. Backup Generators

facility operators to navigate the potential solutions for mitigating and monitoring/quantifying methane emissions. The focus of the technology roadmap will be in 4 areas – 1) mitigation and station design, 2) emissions monitoring, 3) emissions estimation, and 4) emissions reporting.

Results/Status

A spreadsheet-based model was created to evaluate how to estimate potential emission reductions via various pathways. The model serves as a centralized tool to identify the range of mitigation opportunities across a midstream compressor station. A user-friendly high-level visualization of the technology roadmap was developed. The visual roadmap condenses spreadsheet information into a static, organized format showing leak mitigation strategies at varying implementation difficulty levels (standard operating procedure, equipment adjustment, and deployment of new assets). A workshop was held in Tulsa, Oklahoma with the project partner to review aggregated information, collaborate on roadmap design, and discuss use cases. The user interface design and technology roadmap graphic were completed, along with a User Guide document covering assumptions, definitions, and methods.

Natural gas transmission compressor stations are complex systems containing many different types of components and equipment, each with some potential to emit methane. The team systematically explored each of these types of components and equipment to deliver a detailed breakdown of compressor stations that includes extensive information on how to track, measure, and mitigate these emissions, where possible. This reveals the vast number of options available to quantify and mitigate.

Routes to mitigate methane emissions at a compressor station can be separated into three main categories: direct recovery, operational improve-

ments, and upgrades and replacements. Each of these mitigation options must be thoroughly explored by a company to balance the potential for methane emissions mitigation with the intricacies of operational implementation, including costs. The Technology Roadmap Diagram and User Interface Spreadsheet Model developed in this project are aimed at helping operators and companies wade through the options to make the most informed decisions. The preparation of the diagram and the model revealed that the thought of a single easy-to-implement solution for methane mitigation from compressor stations is a nuanced discussion, involving difficult decisions between cost, reduction efficiency, and ease of implementation.

Key Considerations

Key considerations identified in the User Guide include: notable differences exist in understanding emissions from specific equipment and component types across a compressor station; EPA GHGRP and GHGI do not provide insights into current statistics on mitigation strategy implementations across the midstream compression sector; operators will make decisions based on specific site, ease of implementation, and cost of implementation per abatement achievable; implementation costs are evolving and will vary by region, vendor, and site; measurement-informed replacements are an integral strategy implementable across multiple equipment and component types; advanced leak detection technologies can enable leak detection across various equipment/component types not represented in Subpart W requirements.

This project is complete. A Final Report was issued in July 2025.

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Differentiating Sewer Gas from Pipeline Gas

Researchers will lab-test commercially available gas detectors equipped with hydrogen sulfide sensors to determine whether they can reliably differentiate between sewer gas, natural gas, and renewable natural gas at leak sites, enabling more accurate field identification of leak sources.

Project Description

The objective of this project is to lab-test two gas detection devices to determine if they are suitable for differentiating between sewer gas, natural gas, and renewable natural gas (RNG) leaks in pipelines. The data collected will determine which detector is most appropriate for gas leak identification in field conditions. Researchers will procure and evaluate the two detection instruments under controlled laboratory conditions. In Phase 1, hydrogen sulfide was identified as a constituent for distinguishing sewer gas from pipeline gas, used in conjunction with the methane-to-ethane ratio, since historical methods using ethane detection or isotopic ratioing do not work when RNG is in pipeline gas.

Deliverables

Deliverables for this project include a final report summarizing the experimental results, evaluating the instruments' abilities to correctly identify gas leaks, and assessing instruments' performance. Funders will decide if a public report will be prepared.

Benefits

A detector that is capable of differentiating sewer gas from pipeline gas when ethane is not present will allow for identification of gas leaks when RNG is in pipeline gas. Historical leak identification methods using ethane detection or isotopic ratioing do not work with RNG, which does not contain ethane and typically comes from anaerobic



digestion. Instrumentation that detects a variety of constituents such as methane, ethane, and hydrogen sulfide would provide a more effective way to differentiate between sewer gas, pipeline gas, and RNG leaks in the field.

Technical Concept & Approach

This phase focuses on laboratory evaluation of two commercial detectors. Researchers will procure a field-portable detector that measures methane, ethane, and hydrogen sulfide in a single unit, alongside a second detector equipped with a hydrogen sulfide sensor. The team will also obtain the necessary test gases and establish a controlled testing location in the laboratory.

Performance testing will expose both detectors to a range of methane-to-ethane and methane-to-hydrogen sulfide ratios designed to simulate varying %LEL concentrations of natural gas, renewable natural gas, and sewer gas. The evaluation will assess each instrument's ability to provide real-time identification of the gas type causing a leak, along with practical field considerations such as detection limits, reliability, and robustness. Results from the laboratory testing will inform recommendations on which detector is best suited for field deployment in gas leak identification.

Results/Status

Two commercial detectors were procured for lab evaluation. One detector was received in December 2025; the second was expected to arrive in early February 2026.

Historical gas measurement data from Phase 1 and an internal gas quality database were analyzed to determine representative methane-to-hydrogen sulfide concentration ratios ($\text{CH}_4:\text{H}_2\text{S}$) for geologic natural gas, RNG, and sewer gas. Key findings included sewer gas $\text{CH}_4:\text{H}_2\text{S}$ ratios with a mean of 57 and a range of 0 to 140 across 5 unique sites; natural gas $\text{CH}_4:\text{H}_2\text{S}$ ratios with a mean of 1,020 and a range of 224 to 1,820 across 79 unique sites; and RNG $\text{CH}_4:\text{H}_2\text{S}$ ratios with a mean of 1,770 and a range of 1,250 to 2,300 across 440 unique sites. Ethane (C_2H_6) was detected above the detection limit in all natural gas samples but below the detection limit in all sewer gas and RNG samples, indicating ethane content as a potential secondary differentiator. These ratios were used to select representative gas blend concentrations for the detector evaluation.

The testing site was prepared, and a gas blender was identified for creating gas mixtures. A malfunctioning flow controller was identified and scheduled for repair. Testing is expected to begin in early March 2026.

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Leakage Differences between Protected and Unprotected Pipe

This project will determine the factors that contribute to differences in emissions between cathodically protected and unprotected steel pipes and whether any warrant further evaluation. A clearer understanding of these factors could support future targeted studies that inform emission factor calculations for natural gas utilities.

Project Description

This project will attempt to generate a clear understanding of factors influencing emissions differences between cathodically protected and unprotected steel, which currently has a higher emission factor. This will involve a literature review of pipeline materials and the current state of emissions research on protected and unprotected pipe, analysis of publicly available data, and close collaboration with sponsors to better understand any potential leak trends as a function of pipeline material type, age, and level and type of cathodic protection.

Deliverables

The deliverables of this project will include a literature review of findings, data collection and data analysis, and a final report. The final report will summarize findings from the literature review, sponsor engagement, leak data trends, and recommendations for additional phases of work.

Benefits

Natural gas utilities are required to report their emissions annually. With recent changes to the distribution and transmission emission factors, there is a growing need to better understand the underlying

factors that affect how emissions are quantified. A better understanding of these factors could support future targeted studies that inform emission factor calculations.

Technical Concept & Approach

Specific tasks in this project include:

Literature Review

Aggregate research findings on the leak propensities of protected and unprotected pipe, and the impacts of cathodic protection integrity.

Data Collection

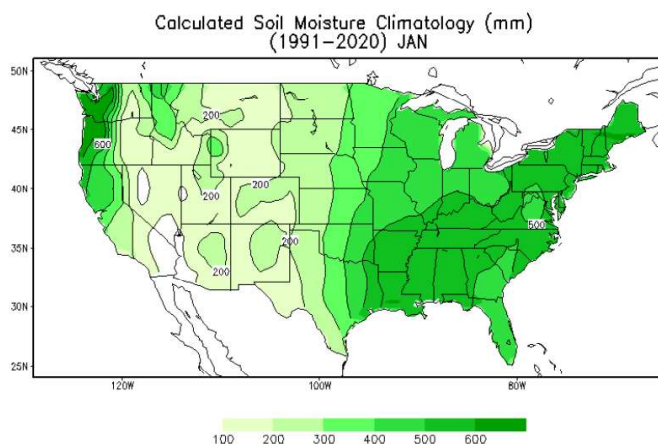
The project team will request information from the sponsors on geolocated pipeline leaks and associated pipeline materials to understand regional factors such as soil conditions, and potential influence of rural vs. urban settings. The team will also request information on cathodic protection inspection and maintenance practices, specifically how often cathodic protection is inspected, and practices for inspecting leaking cathodically protected pipes.

Go/No-go Decision

At the completion of the data collection effort, the team will hold an update meeting with sponsors to discuss a go/no-go decision based on the feedback of sponsors.

Information Review and Data Analysis

Data analysis will focus on identifying trends observable with anonymized sponsor datasets and publicly available PHMSA datasets. Some proposed trends to investigate include determining the average percentage of system inventory for steel categories (both miles of main and number of services), comparing leak rates between operators with above average steel infrastructure and others, analyzing differences between rural and urban areas regarding leak trends and pipeline materials, identifying survey methods used for leak estima-



NOAA Calculated Soil Moisture Climatology (NOAA, 2024)

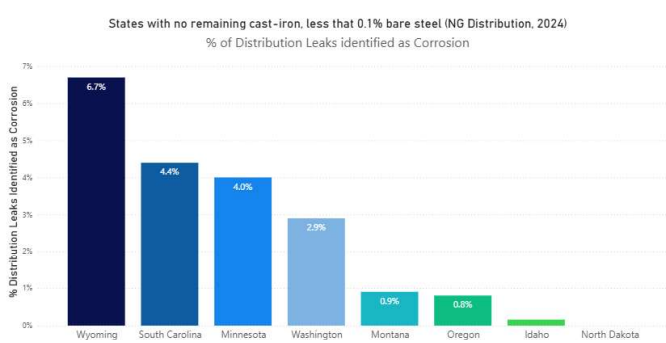
tion, and examining how leak grade, material, age, and repair status factor into reported leaks. The data analysis will also support recommendations in the final report for an additional phase of this project, which can include leak trend validation field studies.

Results/Status

The project completed a literature review of the current state of emissions research on protected and unprotected pipe, engaged with participating utilities to understand company specific maintenance and inspection practices for cathodic protection systems, and analyzed both publicly available and sponsor provided data to better understand potential leak trends as a function of pipeline material type, age, and level and type of cathodic protection.

The literature review examined recent changes to EPA Greenhouse Gas Reporting Program emission factors for natural gas distribution mains and the studies used to justify the new emission factors. It found that protected steel pipe can still experience the full range of recognized leak cause categories despite corrosion mitigation measures. The placement timing and location of cathodic protection systems, interference and stray currents from nearby facilities such as light rail and high voltage AC lines, and third party excavation damage that can create defects which accelerate corrosion. The review also identified limitations in how leaks are reported and surveyed.

Analysis of publicly reported leak data combined with sponsor datasets identified regional and state level patterns that appear to be influenced by a mix of pipe age, material history, coating condition, cathodic protection characteristics, and local operating environments. The West region showed comparatively higher corrosion related reports despite having less remaining cast and wrought iron distribution main inventory, suggesting that



Corrosion trends for states with lowest quantities of cast-iron and bare steel distribution pipe (PHMSA, Pipeline Replacement Inventory 2025)

remaining leak patterns are not explained by a single material category alone. At the state level, several states that have substantially advanced cast iron and bare steel replacement still reported corrosion related leaks; in those cases, leak counts appeared more closely associated with the share of older pre 1970s installed distribution pipe than with remaining bare steel inventory. Sponsor data also indicated that protected coated steel distribution mains can have lower leak per mile ratios than protected bare steel and unprotected coated steel, highlighting the value of external coatings and the need to evaluate multiple asset characteristics together rather than using leak occurrence as a direct measure of operator performance.

The final report recommends that future research focus on acquiring more accurate pipeline inventory and cathodic protection datasets. Follow on work should examine the impacts of pipe age and of interference currents on protected steel mains, including additional review of the AC and DC sources that can affect natural gas distribution pipe.

This project is complete. A Final Report was issued in September 2025.

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Hydrogen Monitoring Solutions

This project will review existing and emerging solutions for monitoring hydrogen in distribution systems, spanning pure hydrogen and hydrogen natural gas blends and application types from in-line measurement to continuous and point sensing. The work will help LDCs identify monitoring options that support operational savings and safety as they expand hydrogen distribution and blending.

Project Description

This project will include a literature review of existing hydrogen sensing and monitoring methods, along with a market review of vendors and technological applications currently available or in development. Advanced solutions already identified for further investigation include distributed acoustic sensing, advanced pressure monitoring systems, continuously monitoring fixed sensors, and optical detection systems.

Deliverables

Project deliverables include a final report describing existing and emerging hydrogen monitoring solutions, summarizing maturity level, feasibility in different use cases, and prospective costs. The report will provide guidance on possible solutions that LDCs could employ in hydrogen network operations.

Benefits

This project will identify monitoring solutions that could generate operational savings and maintain safety on future hydrogen networks as utilities look to enhance both their pure hydrogen distribution and blending capabilities.

Technical Concept & Approach

Specific tasks in this project include:

Background & Literature Review

The task includes review of available comparison studies on existing hydrogen monitoring solutions and test data from previous OTD-SMP projects involving hydrogen sensors. The team will conduct a search of the market for off-the-shelf or near-commercial monitoring technologies.

Sponsor & Vendor Discussion

This task will include discussion with sponsors about any pending needs regarding their existing or future efforts for hydrogen monitoring. The team will conduct vendor outreach on the application of their advanced monitoring solutions or future collaboration in a field study, if possible.

Results/Status

To provide background and context, the underlying technologies behind hydrogen sensors were investigated, examining the benefits and drawbacks of various detection methods. The team also reviewed LDC related hydrogen case studies that demonstrate growing interest within the natural gas industry in hydrogen systems.



Assorted Fixed Hydrogen Detectors

A comprehensive literature review was conducted, highlighting the growing body of research published within the last two years by academic institutions and industry on hydrogen impacts to the gas system and on advancements in detection technologies. The literature review was organized into two



Assorted Handheld Hydrogen Detectors

sections: one identifying and summarizing relevant literature for hydrogen leak detection and monitoring, and another identifying mature hydrogen monitoring devices that are commercially available. The academic and commercial review covered three parts: a review of existing technologies, emerging technologies, and relevant regulations. The emerging technologies review covered continuous onsite monitoring, distributed temperature sensing, and high resolution standoff detection, and the regulations review identified codes and standards from ISO, ASME, NFPA, and IEC.

The review produced a qualitative comparison between sensor types, including electrochemical, catalytic, resistance based, thermal conductivity, work function, and optical sensors, across metrics such as selectivity, response time, detection range, lower detection limit, environmental sensitivity, market availability, and operational lifetime. Devices and methodologies were divided into four parts: fixed (in-line or open air); handheld, portable, and personnel detectors; flame detectors; and network monitoring solutions that integrate multiple technologies. Fixed detectors were found to be the most common for detection near hydrogen storage tanks and employ a range of sensor types including electrochemical, thermal conductor, catalytic bead, ultrasonic, and MEMS technologies, while handheld and portable detectors primarily use thermal conductivity, electrochemical, and catalytic bead sensors. The review also noted that gas concentration monitors can enhance safety throughout the supply chain, with measurement important at three distinct points: the injection point, to ensure desired hydrogen percentages; distribution and end user sites, primarily for quality control; and hydrogen and natural gas separation, to verify hydrogen quality.

The technology review provided descriptions, possible use cases, and estimated costs, where available, for 40 commercially mature hydrogen detection instruments. These instruments cover an array of uses and can be deployed throughout a utility's system in the form of in-line process analyzers, atmospheric detectors, ultrasonic monitors, and handheld detection instruments. Vendor outreach revealed that some instruments had been delayed due to pending intrinsic safety certification for gaseous, combustible environments, and that some discontinued instruments can be procured only on the resale market.

The review identified a wide range of commercially available monitoring solutions for utilities interested in deploying or expanding hydrogen based systems, with options covering nearly every segment of a pure or blended hydrogen value chain. The literature review and technology evaluation identified dozens of instruments and resources to enhance an LDC's confidence and understanding of pure hydrogen and hydrogen natural gas blends and the methods available to monitor them safely.

The Final Report identified several directions for future work. Future phases could explore flame detectors or network monitoring solutions that integrate multiple technologies in more depth, examine safety centered and technology agnostic solutions, and conduct targeted testing of selected instruments to assess their hydrogen sensing capabilities and effectiveness under various environmental conditions.

This project is complete. A Final Report was issued in September 2025.

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MET Collaborative Program

This project will enhance the Methane Emissions Toolbox (MET) web application with new capabilities for multi-tiered sample planning and company-specific emissions factor estimation, enabling LDCs to compare monitoring approaches for developing annual emissions inventories and track company-specific emissions factor estimates over time.

Project Description

Phase 2 of MET will include Release 3 of the web application, which will provide two new tools for emissions measurement data analysis and sample planning. The first tool will allow LDCs to compare the relative effectiveness of various multi-tiered methane monitoring approaches for developing annual emissions inventories. The second tool will use emissions measurements taken over multiple campaigns to create visual summaries of the results, allowing a comparison of changes in the emission rates across campaigns and providing a pooled company-specific emissions rate estimate.

With the advances in methane emissions detection and quantification technologies, there has been greater emphasis on using measurement data to compute emissions inventories within both EPA's GHGRP Subpart W required reporting and voluntary emissions programs such as Veritas and OGMP 2.0. Phase 2 will also include revisions to existing tool outputs to improve readability, and verification of activity factors and expected emissions distributions using scientific literature.

Deliverables

Deliverables for this project include an updated sample planning template spreadsheet with reviewed activity factor and emission factor values, documentation on default value choices, and improved histogram outputs for both tools. Additional deliverables include a functional specifications document describing all required functionality for the multi-tiered sample planning tool and deployment of both the new multi-tiered sample planning tool and the new company-specific emissions factor analysis tool within the online toolbox.

Benefits

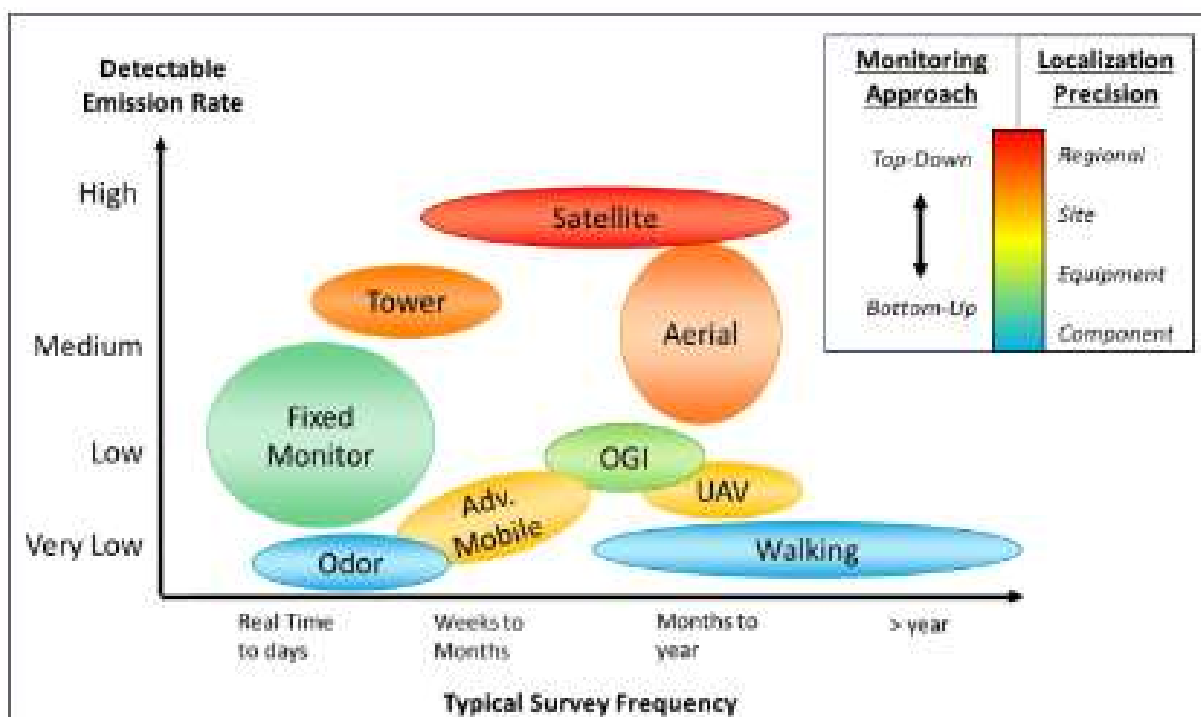
This project will allow LDCs to compare the relative effectiveness of various multi-tiered methane monitoring approaches for developing annual

emissions inventories, improving decision-making and decreasing costs. Analytical tools like MET can process emissions measurement data, leading to increased efficiency in translating raw measurement data into inventories. With the advances in methane emissions detection and quantification technologies, there has been greater emphasis on using measurement data to compute emissions inventories within both EPA's GHGRP Subpart W required reporting and voluntary emissions programs such as Veritas and OGMP 2.0.

Technical Concept & Approach

The team will execute Phase 2 enhancements to the Methane Emissions Toolbox (MET) web application in a sequenced series of tasks. Work begins with reviewing and updating the initial activity factors and emission factors provided as defaults in the template spreadsheet to determine if they align with current scientific literature, and developing documentation with references and justification for each choice. Alongside this, the team will review and recode histogram outputs for both the uncertainty quantification and sample planning tools so that bin sizes are based on the data shown and/or are changeable within the visualization, improving readability based on sponsor feedback.

The team will then proceed to full design of a multi-tiered sample planning tool for creating emissions inventories that reflect existing monitoring campaigns by LDCs (e.g., monthly advanced mobile monitoring, annual walking surveys, and weekly satellite). Design considerations include what monitoring technologies to build into the tool, the degree to which monitoring efforts can be specified spatially and temporally, and the spatial representation of the LDC assets in the model. Following design, the team will implement the tool into a software program that efficiently executes the simulations and incorporate that program into the online toolbox with an online interface.



The final task involves developing and implementing a new data analysis tool that uses emissions rate measurements collected over multiple years for a single component type or asset class. This tool will provide emissions factor estimates and uncertainty bounds for each year, as well as a pooled estimate aggregating the data across all years. The tool will allow LDCs to track company-specific emissions factor estimates and uncertainties over time.

Results/Status

The initial Sample Planning tool partitioned infrastructure based on predefined categories (e.g., services by material type: plastic, cast iron, protected steel). Based on sponsor feedback, the project team added flexibility to allow users to input custom infrastructure groupings, letting each company describe their system using their preferred classifications. The toolbox documentation was updated with expanded details on the default emission factor and activity factor values used in the Sample Planning tool, and it now describes how to use custom infrastructure groupings with the Sample Planning tool.

An issue causing the Uncertainty Quantification tool to hang when processing large numbers of emissions measurements was resolved, and the tool now performs reliably with larger datasets. The histogram visualizations for the Uncertainty Quantification tool were recreated to improve the read-

ability of the results.

The project team completed development of the analytics workflow for the new tool that tracks emissions factor estimates over time. The workflow ingests multi-year emissions measurements for a single component type or asset class, estimates the emissions factor for each year individually, and creates pooled estimates using all available data.

Development of the user interface for the emissions factor tracking tool, which will incorporate the completed analytics workflow into the toolbox, is underway.

A new tool for visualizing probability of detection (POD) curves is in development. All methane emissions measurement technologies have performance limits, often reported as a limit of detection, the smallest methane concentration above ambient levels that can be detected with confidence. In reality, there is a spectrum of emission concentrations for which a device has imperfect detection. With increased testing of devices, the POD curve can be characterized. The new tool is intended to aid in a more comprehensive understanding of a device's capabilities.

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PHMSA Cost Share: Gap Analysis to Identify Opportunities to Inform Leak Detection and Repair Programs in LNG Facilities

Researchers will conduct a gap analysis of federal and state leak detection and repair (LDAR) regulations, standards, and best practices for U.S. LNG facilities, and assess the feasibility of a centralized, publicly accessible portal for leak and emissions data. The analysis will identify regulatory gaps and duplications as well as opportunities for operators to reduce compliance burdens, streamline operations and reporting, and support effective LDAR programs that drive down methane emissions.

Project Description

The project team will perform a gap analysis of LDAR federal and state regulations that apply to LNG facilities and identify regulatory gaps and duplications, as well as future opportunities to reduce regulatory compliance burdens for U.S. LNG operators. The analysis will identify industry standards and best practices, and LNG facilities reporting requirements for leaks. The secondary objective is to assess the feasibility of a centrally located, publicly available portal to disseminate findings of leak and emission data from LNG facilities.

Natural gas leaks from liquefied natural gas (LNG) facilities and operations pose safety concerns and environmental hazards due to the property characteristics of methane (CH₄), the main component of LNG. To mitigate natural gas leaks, reduce potential safety incidents, and environmental risk through CH₄ emissions the United States (U.S.) has passed two key pieces of legislation: the Protecting our Infrastructure of Pipelines and Enhancing Safety Act of 2020 (PIPES Act), and the U.S. Methane Emissions Reduction Action Plan, through the Inflation Reduction Act. Mentioned in both, a fundamental method for reducing natural gas leaks is an effective LDAR program. Compounding the regulatory changes that have occurred, PHMSA has issued New Proposed Rule Making (NPRM) in 2023 for advanced LDAR programs.

Currently, there is no comprehensive public database for leak detection and emissions measurements for the LNG segment that combines both sources. The challenge is the data collected in LDAR programs and emissions measurement are not reported in the same standard way.

Deliverables

Deliverables for this project will include a final report presenting the gap analysis comparing LNG

facilities and an assessment of the feasibility for a publicly accessible portal for leak and emissions data. If feasible, deliverables will also include a hypothetical system design for the portal with workflow processes and information technology components.

Benefits

As additional LNG facilities are constructed, PHMSA and other federal and state agencies are focused on helping reduce emissions from these facilities. This project will help identify regulatory gaps and duplications, identify industry standards and best practices, and support an effective LDAR program that drives down CH₄ emissions, retains product, and thereby supports DOT PHMSA's mission to protect people and the environment by advancing the safe transportation of energy.

The results of the gap analysis may identify duplicative work being performed to meet state and federal requirements and may also identify practices to streamline operations and reporting. This will also create consistency in reporting and managing existing LNG facilities.

Technical Concept & Approach

The effort needed to accomplish the project's objectives is divided into three project goals (knowledge gathering, gap analysis, and a centralized and publicly accessible portal) and associated milestones. A Technical Advisory Panel (TAP) consisting of operators, subject matter experts, technology providers, academic experts, and LNG stakeholders will be established to understand best practices and disseminate findings, and will provide input into project scoping.

The team will leverage its network as well as the project's cost share partners OTD and Veritas to reach operators, LNG stakeholders, and leak de-

tection and repair subject matter experts, and will meet with TAP members every other month for the duration of the project.

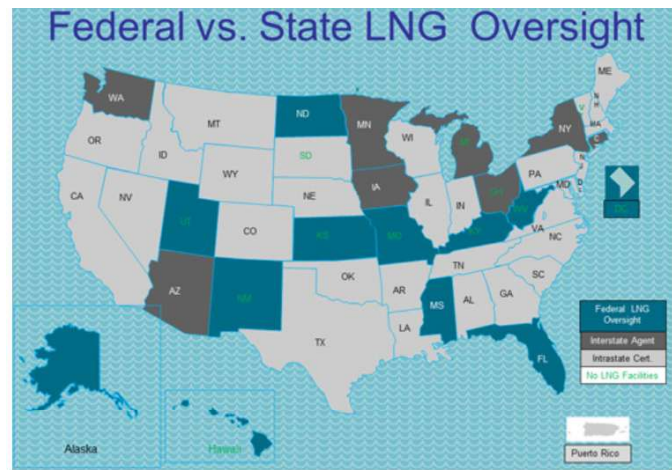
The work will also include a literature review of existing federal and state regulations, safety, environmental, reporting requirements, standards, and best practices for the U.S. LNG facilities. As was done with prior GTI gap analysis for PHMSA, the team will develop a matrix comparison model to compare the applicable regulations and voluntary standards and conduct a survey of LNG stakeholders. To perform the gap analysis, an artificial intelligence approach supported by subject matter experts will be utilized to understand the connections whether it is gaps or duplications between the regulations and best practices.

To construct the assessment for feasibility of a centralized and publicly accessible portal from the findings and reports on leak and emissions data, the team will first gather requirements from LNG stakeholders, LDAR technologies, regulatory standards, portal function requirements, and any other requirements gathered from TAP members. Next, an assessment of data management for the portal will be performed. LNG operators typically own the data they collect, and therefore the public would have no rights to the data. Lastly, if feasible the team will draft a hypothetical system design for the portal.

Results/Status

In 2025, the project conducted an analysis of LDAR regulations, industry practices, and data sharing feasibility for LNG facilities. A two pronged regulatory assessment, combining a survey of nine LNG operators representing over 80% of U.S. liquefaction capacity and a detailed federal and state level regulations matrix, revealed generally robust regulatory coverage with some duplications across federal, state, and proposed rules. The survey captured operator perspectives on LDAR requirements, work practices, voluntary initiatives, and considerations for public data sharing. The regulations matrix evaluated 6 federal and 14 state codes and compared key elements such as thresholds, frequency, technologies, and reporting. Insights from both were synthesized to identify gaps, alignments, and best practices, and a feasibility study evaluated the potential for a centralized public LDAR data portal, including data, user, system design, and risk considerations. These findings informed a set of recommendations for PHMSA.

From the operator survey, no single regulation was



Federal Oversight of LNG Facilities (source: Natural Gas Center of Excellence for Liquefied Natural Gas Safety-Report to Congress¹⁸)

Blue: Federal, Dark Grey: Interstate Agent, Light Grey: Interstate Cert., Green text: No LNG facilities

universally applicable to LDAR programs at LNG facilities; instead, facilities often cited state level requirements and air permits. Operators also noted the existence of duplicate reporting requirements. The survey showed that the most common technology for LDAR was optical gas imaging (OGI). Some operators participate in additional voluntary activities beyond what is mandated, such as increasing surveying frequency, performing quantitative measurements, achieving shorter repair times than required, and testing alternative measurement technologies not mandated for them.

Trends were identified with the state codes along the categories and questions that were in the matrix. It was found that the states primarily focused on emergency or large leak events for reporting rather than routine detection procedures like what is seen in the federal regulations like 49 CFR Part 193. Initial gaps were identified, one being inconsistent and vague nomenclature for facility types and varying survey frequency and reporting requirements.

The project team presented at the Americas LNG Summit in Lake Charles, Louisiana on October 21, 2025, covering the technical approach, preliminary results, the operator survey, preliminary regulations matrix conclusions, and the feasibility assessment for a data portal.

The first draft of the final report was completed by the team in December and is under internal, academic, and TAP review.

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Leak Survey Instrument Standards and Test Protocol

Researchers will develop performance standards for walking leak survey instruments that use a pump or an open path laser, along with laboratory testing and controlled field testing procedures. The standards will give utilities confidence that an instrument and method are suitable for leak survey, and give technology providers clear testing and performance requirements to meet before new products enter the LDC market.

Project Description

This project will develop standards of performance for pumped and open path laser leak survey instruments, lab testing procedure for the instruments, and controlled field testing procedures for the instruments.

Walking survey instruments primarily rely on either a pumped or open path laser gas detector. Leak survey pumped instruments have been around since the 1940s with current generation of instruments using methane specific technologies since the mid-2000s. Methane specific open path lasers were also introduced in the same period. Validation testing and adoption of the new technologies varied. For example, pumped instruments were validated through comparison to existing instruments (i.e. similar sensitivity, pump flow, and reaction time) and through limited field testing with individual LDCs, while the open path laser validation involved extensive multi-year testing which included laboratory measurements, single blind, and double-blind leak surveys. This extensive validation process was required in part because the survey method and technology were novel to the industry.

Since the mid-2000s, multiple new technologies and instruments have been introduced to the LDCs with limited or unknown levels of validation. As the rate of innovation has increased, it has become exceedingly more difficult for the industry to test and evaluate if something new is better or worse than current methods and instruments. Currently, the only leak survey performance specification was established in the GPTC, and PHMSA has taken the ppm sensitivity and proposed that it become the minimum performance standard. The NPRM proposed a specification of 5ppm sensitivity as the only criterion for a leak survey instrument. This is one of many important specifications required to achieve a reliable detection rate while surveying. This project will focus on the development and

testing of performance specifications and leak detection performance for the following instrument group: walking survey instruments that use a pump to draw a gas sample from the ground into a closed cell within the instrument, and walking survey instruments that use an open path laser to scan the ground.

Deliverables

Deliverables for this project include standards of performance for pumped and open path laser leak survey instruments, along with a lab testing procedure and controlled field testing procedures for the instruments. The project will also produce an analysis and report of the findings.

Benefits

Historically, the industry has relied on experience and vendor provided information to adopt one leak survey instrument over another. PHMSA's proposed rule will establish a single performance specification for all leak survey instruments. Additional specifications are needed to establish requirements for vetting leak survey instruments. Establishing industry approved standards with clear performance specifications and test procedures will enhance the quality, competition and leak survey confidence. Establishing instrument performance specification and leak detection performance levels will provide confidence that an instrument and method are suitable for leak survey.

Having a standard will also reduce the cost and barriers to develop and incorporate new products which will encourage competition. Further, technology providers will have clear testing and performance requirements that must be achieved before introduction to the LDC market. Establishing performance standards and validation procedures has become an expectation to use and adopt new technologies and methods.

Point and Click Laser



Pumped



Technical Concept & Approach

The team will establish contact with leading instrument technology providers to build collaborations. Based on technology provider inputs, key functional parameters and specifications that have first order effects on leak detection will be established. The team will also establish controlled laboratory testing procedures to measure the key functional parameters, and will conduct laboratory testing of core instruments to validate the procedures.

Additionally, controlled field testing procedures will be established to measure the leak detection rate of the instrument. The team will establish a leak underground and above ground test bed with controlled leak rates. Controlled leak detection tests will be conducted at the test bed to validate the process.

Results/Status

This project began with a survey of sponsors to understand some of the vendors and instruments they currently use to guide vendor collaborations. Technology vendor participants were identified, and meetings with multiple vendors have been conducted to discuss the project and factors that they believe are important to include. Discussions covered instrument, environmental, and human factors, including proper training and instrument user interface.

Key performance factors compiled from previous OTD projects and vendor input were developed into two testing protocols, one for pumped instruments and one for open path lasers, and shared with vendors. These protocols outline what each factor represents and how to test it in a reliable, repeatable manner. They outline the experimental setup for lab and field testing to determine important metrics on performance such as the accuracy and drift using calibration curves, the purge rate

and response rate using high concentration sampling, and the probability of detection (POD) in lab settings and field settings with above and below ground leaks. Bias, resolution, and detection time are additionally addressed, with wind testing, range, and battery impacts included for open path lasers only. The protocols also clearly describe how metrics should be represented to avoid ambiguity.

Controlled field testing for above and below ground leaks is also described to estimate the POD and detection time in field conditions. As not all environmental factors can be tested (wind, temperature, humidity, soil conditions/moisture/type, etc.), it is instead recommended to clearly describe the conditions present during testing and to test under the extremes provided as appropriate operating conditions.

The team has received vendor feedback on the current protocols and worked to address the comments received. The following work will be the focus: discussing testing protocol with vendors; discussing testing protocol and the key factors with sponsors; addressing any recommended changes to the protocol from vendors or sponsors; working through required logistics to begin implementing the testing protocol for a subset of instruments; and initiating framing performance standards for these factors.

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Xplorobot Laboratory Testing

Through laboratory and controlled field testing, researchers will work with Xplorobot to evaluate the performance and possible use of its handheld open path laser methane detector and imager for leak survey and emission rate measurements in LDC applications. This independent testing will give utilities confidence in adopting instruments that can not only detect leaks during a leak survey but can also estimate the emission rate, as PHMSA and EPA regulations prioritize leak repair on that basis.

Project Description

Xplorobot is a new handheld open path laser methane detector and imager. The device can detect leaks and estimate the emission rate of the leak. This project will evaluate its performance and possible use for leak survey and emission rate measurements. Laboratory and field testing will be performed.

This project will coordinate with work in proposed 7.25.d Leak Survey Instrument Standards and Test Protocol. To the extent possible, the protocols and facilities from that project would be leveraged for this project.

Deliverables

Deliverables for this project will include a final report documenting the laboratory and field testing to evaluate the Xplorobot instrument's performance and possible use for leak survey and emission rate measurements.

Benefits

Methane leak detection and emission reduction is core to the gas industry. PHMSA and EPA regulations are prioritizing leak repair based on the emis-

sion rate of individual leaks. Having instruments that can not only detect leaks during a leak survey but can also estimate the emission rate will inform and support actions taken to reduce emissions. Independent testing of new instruments/technologies will provide confidence in developing and adopting new systems.

Technical Concept & Approach

This project will evaluate the Xplorobot methane leak detection laser optical gas imager instrument recently introduced in the commercial market, and will have two parts. The instrument will first be evaluated in the lab and in controlled outdoor field conditions. If the results of this first part are favorable, sponsors can proceed with additional field testing at a sponsor training facility in the second.

The team will work with Xplorobot to plan and coordinate laboratory and field testing activities, and articulate data sharing arrangements, restrictions and non-disclosure. Xplorobot will provide an instrument for testing. The team will test the instrument in the laboratory and in outdoor controlled leak conditions at the pipe farm.

With the findings in Part 1, sponsors will be given the option to proceed with further field testing (Go/No-Go). The project team will present results of Part 1 in a sponsor update and solicit responses before proceeding to Part 2.

If supported by sponsors in the Go/No-Go decision, field testing would be conducted at a sponsor training facility site where controlled release conditions are available, and sponsors will be asked to provide the site. One field testing event at one sponsor site is envisioned. Testing would occur only at the training facility and would not include leak surveying in an LDC service area as part of this effort.



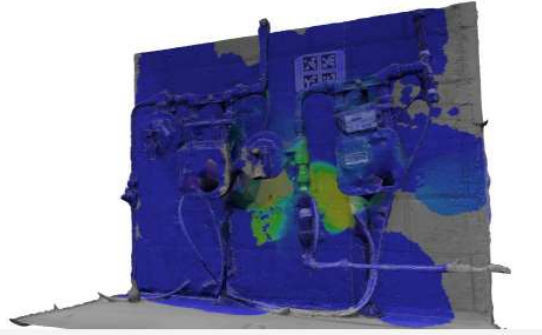
Xplorobot Laser Optical Gas Imager

Results/Status

Xplorobot visited the test facility in September 2025 with three models of their device for testing. This included the original Rover model, and two versions of their newer Genesis model: one with the same field of view as the Rover (Genesis narrow) and one with a wider field of view (Genesis wide). Xplorobot suggests the device(s) can be used in multiple ways, including for detection, for quantification, and to build photogrammetric models (i.e., a digital twin).

A series of tests was completed with the Xplorobot team to understand the instrument and its ability to detect and quantify emissions. This included Tedlar bag testing with known concentrations, controlled leaks from threaded connections of known flow rate, and testing on a meter set assembly with leaks of a known flow rate. Testing also included the Xplorobot team demonstrating how they can visualize leak plumes and recreate a leak site using photogrammetry modeling. These tests were accomplished on a simulated thread leak and controlled leaks around a meter set assembly. Xplorobot also demonstrated their system's ability to quickly identify components from imagery and tag them with each component's location. An example photogrammetric 3D model was produced (a model that can be rotated, with the option to overlay measured plume data).

Field testing was limited to the pipe farm with a sand pit that has buried pipe designed to simulate single point or multi point leaks. Several controlled underground leaks were tested to understand Xplorobot's detection and quantification performance for both single and multi point leaks. Testing also included demonstration of the visualization and photogrammetry modeling with the underground leaks. An example visualization from their dashboard (equivalent to what can be seen on the device) was captured.



Controlled flow rate tests were performed using a mass flow controller connected to a pipe with a loose cap. The angle between the device and the Tedlar bag was tested for 3 concentrations for each device as this is known to affect other open path laser devices. The effect of distance on the concentration measured was tested using the same setup as the quantification testing. A 0.04 scfh leak was tested at 2, 4, 6, and 8 m. Larger distances could not be reasonably tested in the lab.

Brief summaries of the results have been provided to sponsors in update presentations. A sponsor update was planned for January 2026 to discuss a go/no go decision on additional field testing, with GTI Energy recommending testing at a sponsor training facility. Assuming the go/no go decision is to continue testing, Xplorobot will be contacted to meet with sponsors and testing at a sponsor training site will be planned. This testing will be focused on different environmental conditions as possible, time and accuracy of leak detection, and performance for below grade underground leaks.

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Microbiological Acceptance and Detection Limits

Researchers will refine quantitative polymerase chain reaction (qPCR) methods for detecting corrosion-causing microbes in renewable natural gas by establishing detection limits, evaluating sample hold time effects, and collecting field data from natural gas facilities to inform microbial acceptance criteria for RNG.

Project Description

This project is intended to address areas of uncertainty regarding microbial testing of RNG streams by performing lab testing to determine detection limits for MIC (microbiologically influenced corrosion)-associated microbe testing and setting guidelines for sample handling and shipping. The project will also expand the dataset of microbiological levels in natural gas to make a better comparison to RNG, with this data used to propose more informed acceptance criteria for RNG.

Microbiologically influenced corrosion is the acceleration of the deterioration of materials owing to the presence of microorganisms and biofilms on their surface. Multiple types of microbes attributed to MIC also play a key role in anaerobic digestion or have been found in RNG gas streams. GTI Energy developed and continues to use quantitative polymerase chain reaction (qPCR) testing to target and quantify MIC microbes in RNG. At present, the detection limit for this qPCR method is based on the non-template control run with each test, and in either scenario the effects of error from sample collection and DNA isolation are not accounted for. Investigations into the effect of increased storage times on collected samples have not been conducted,

though there is the potential for sample loss and overestimation due to bacterial growth.

The project will also collect field samples of geologically derived natural gas to compare against gas from RNG facilities, building on GTI Energy and OTD's Trace Constituent Database. At present, there have been too few natural gas biological samples to accurately make this comparison. This expanded dataset will provide a basis for utilities to establish biological acceptance criteria for RNG.

Deliverables

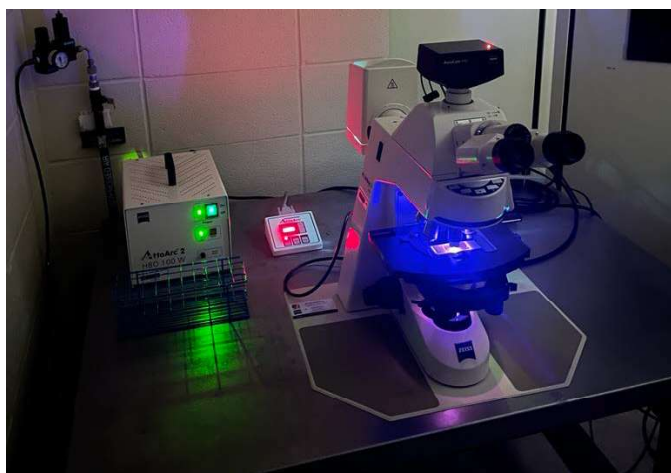
Deliverables for this project include determined detection limits for the qPCR MIC testing method, hold time effect data and updated sample handling guidelines, and a field sample comparison dataset of natural gas vs. RNG microbial levels.

Benefits

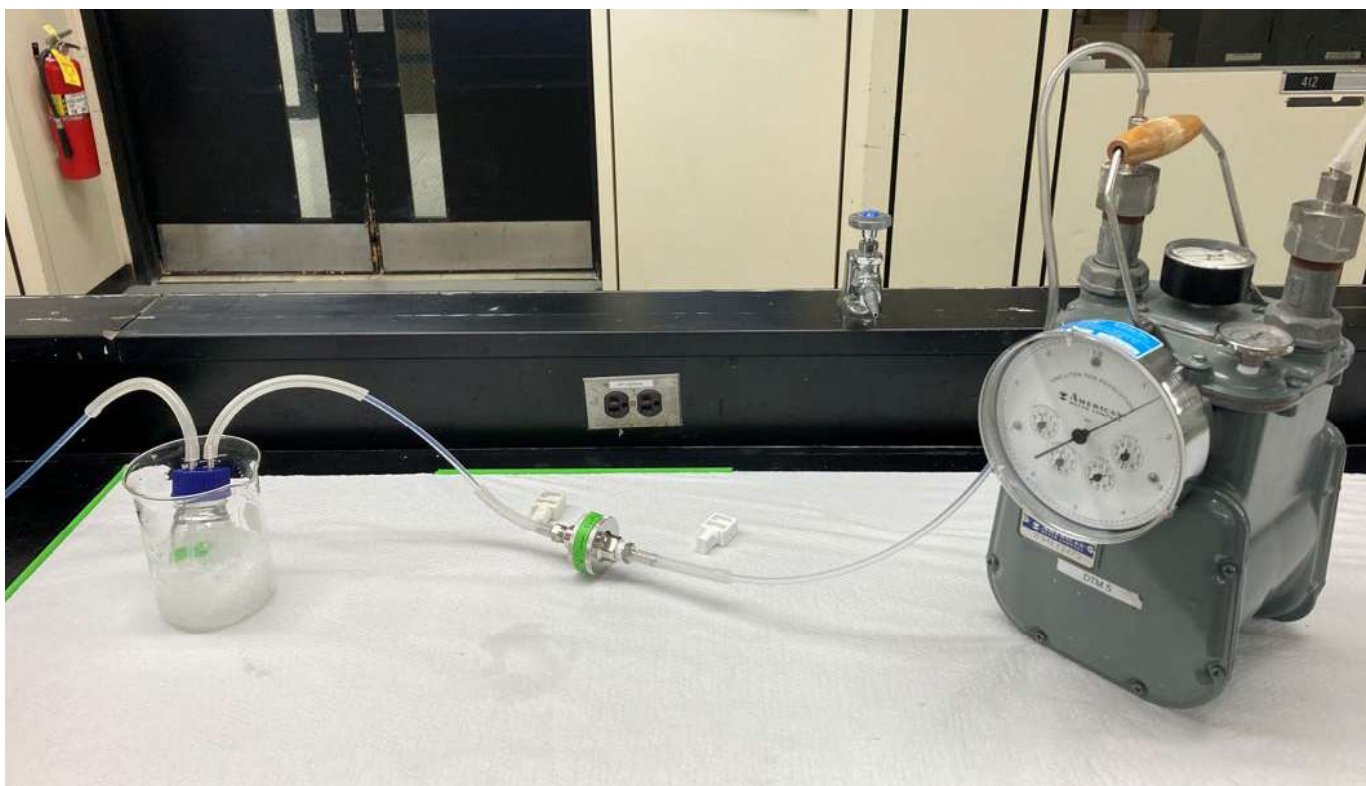
In the past five years, RNG operational facilities have grown three-fold in North America. Refining the test method to detect microbes in RNG gas streams, solidifying testing guidelines and recommendations, and providing more field data on the microbes present will help utilities determine RNG acceptance criteria and ease the burden on companies offering renewable natural gas to the market. Comparing bacteria levels in geologically derived natural gas to RNG provides the data needed to determine biological acceptance limits, allowing the use of this clean energy source.

Technical Concept & Approach

The team will address areas of uncertainty regarding microbial testing of renewable natural gas (RNG) streams through laboratory testing and field sampling. Researchers will first develop a testing apparatus capable of passing gas streams with a "known" quantity of bacteria through the sampling setup, building on prior work that routed gas through an established liquid culture of microorgan-



Zeiss Axioskop 2 plus fluorescence microscope



Biological gas sampling device displayed in the lab.

isms. A similar setup will be used for this project.

Once validated, the detection limit will be determined through replicated testing. Replicates of differing dilutions of spiked gas sample will run through the testing apparatus and undergo established DNA isolation and quantitative polymerase chain reaction (qPCR) methods to determine the lowest concentration of bacteria that are reliably quantified. Established methods to determine the limit of detection (LOD) in the biotech industry will be utilized to guide this task.

The team will then conduct a hold time study using the same apparatus. Samples will be taken and held for different time intervals to determine the effect of hold time (e.g., 1-day, 3-day, 1 week, 2-week). The samples will be tested similarly (DNA isolation, qPCR) and compared to samples with a zero day hold time. This data will be used to update or strengthen existing guidelines for sample handling and shipping.

In parallel, researchers will collect field samples of geologically derived natural gas from gathering lines, points of use, and points near production facilities. The samples will be analyzed using DNA isolation and qPCR testing method. The Trace Constituent Database will be utilized for comparison against RNG data. This task will require coordination with project sponsors to allow gas collection at their facilities.

Results/Status

Three strategies for inoculating a gas stream with bacteria were discussed: passing gas through a contaminated pipe, through an active liquid culture, or directly injecting fluid containing bacteria. The team progressed with the liquid culture approach.

Dedicated sampling equipment was received and a fluorescence microscope was brought online to validate qPCR bacteria counts. Three experiments were performed using the original culture and 1:10 and 1:100 dilutions, with samples collected for DNA isolation and qPCR analysis. Gas was sparged through the culture liquid and filter holder in series, and both liquid aliquots and filters underwent DNA isolation and qPCR amplification for total bacteria.

An additional trial was completed using field pressures (10 psi). Due to the higher pressure, fluid from the culture entered the filter holder, leading to inconsistent results. The apparatus design had not adequately replicated field conditions. Validation of the apparatus was scheduled for mid Q1 2026, with detection limit testing and field sampling at natural gas sites to follow.

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New Emission Factors for LDC Pipelines

Researchers will leverage existing data from multiple local distribution companies to develop updated national-scale emission and activity factors for LDC infrastructure. Updated factors will support more accurate reporting of company methane emissions and inform decisions on infrastructure replacement efforts.

Project Description

Researchers will leverage existing data collected by local distribution companies (LDCs) to develop updated emission and activity factors for LDC infrastructure that can be used to produce more accurate reporting of methane emissions.

Emissions and activity factors for LDC infrastructure are based on aging studies (Lamb et al. 2015) or limited data (Weller et al. 2020). A previous study estimated methane emissions from U.S. local distribution natural gas pipes using data from advanced mobile leak detection (AMLD) equipment, leveraging data from over 4,000 leak indications and emission rate estimations coupled with utility pipeline GIS information. That study found interactions between pipeline material, age, and leakiness, with the leakiness of all material types increasing with age. The estimated national emissions from pipeline mains in local distribution systems were five times greater than that of EPA's greenhouse gas inventory. The resulting emissions factors were adopted by the EPA in 2022.

The effort will collate data from multiple AMLD survey providers, collect relevant member data into an anonymized data pool including direct emissions measurements and follow-up investigation results, and integrate these data to develop a new set of national-scale LDC emission and activity factors for specific asset categories such as plastic mains, plastic services, and steel mains.

Deliverables

Deliverables for this project include a new and improved set of national-scale LDC emission and activity factors for specific asset categories (e.g., plastic mains, plastic services, steel mains), a final report and presentation, and a draft of a paper for a scientific journal publication.

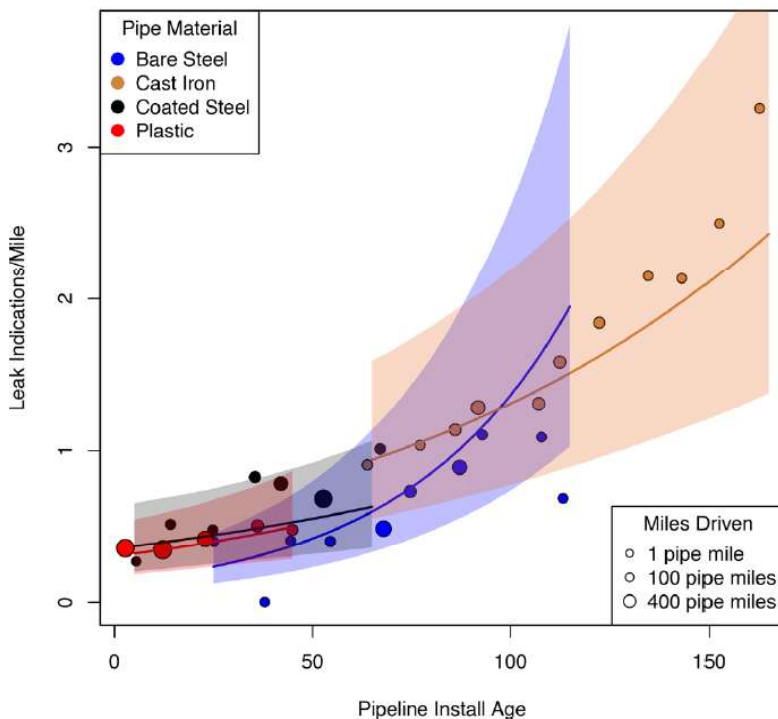
Benefits

Emissions and activity factors for LDC infrastructure are based on aging studies or limited data. Harnessing industry data to update these factors can provide companies with defensible responses to leverage new emission. An improved understanding of factors affecting leak and emissions patterns can inform decisions on infrastructure replacement efforts, saving time and cost. Updated factors can also be used to improve emissions and activity factors reported to EPA or used in EPA emissions calculations.

Technical Concept & Approach

A key feature of the approach is to leverage data already collected or being collected as part of LDCs' current practices, with LDCs performing the data queries so the data are readily anonymized with minimal transfer of sensitive information.

For each participating LDC, the team will work collaboratively to collect information on advanced mobile leak detection and other survey results from service providers to obtain leak size and attribution information. Each AMLD indication will then be linked to any leak discovered by follow-up investigation. The source of the leak and the properties of the infrastructure will be identified, including the



material, pressure, any protection, such as a plastic coating or cathodic protection, and the vintage. A statistical analysis similar to one developed in prior work will then be conducted to estimate the activity factors (i.e., leaks per mile of pipeline of that type and age) and emission factors (i.e., gas emission rate per leak).

The team will reach consensus with project sponsors on data related to the pipe system and leak characteristics used in this study, and data-sharing agreements, including methods for anonymizing data, will be finalized before data queries are executed. Team members may travel to partner sites during data querying, with up to six trips planned for project team members to meet and develop data queries with LDC contacts. Data management efforts will ensure secure transfer, storage, and access, and will focus on preparing the data for analysis by performing data quality checks and exploratory analyses, including removing or correcting data as needed, creating metadata by merging data sets, and controlling quality to ensure reliable modeling results.

Additionally, appropriate data mining and statistical methods will be identified and developed to explore the data and model the outcomes. This

will involve applying mining techniques or models to analyze the data, verify modeling assumptions, and generate tables and graphics. The project team will share the key findings and results from the data analysis and modeling for review, with opportunities for sponsors to provide feedback and guidance on the results.

Results/Status

The project team spent 2025 focusing on engaging project partners and soliciting data to support the objectives. The team engaged OTD members and AMLD service providers via emails, phone calls, and meetings to request and collect data. A tracking document was created to monitor progress on partner engagement. The team identified

16 different operators or AMLD service providers engaged for data sharing. The team engaged with project partners at the GTI Energy SAGE Conference and at the AGA fall committee and operations meetings.

The team collected a comprehensive data set from one operator in collaboration with the operator's service provider. The team received a sample data set from one AMLD service provider and performed exploratory analysis to identify issues and ask clarifying questions; communications with the service provider resolved issues. Exploratory analysis was performed on the two data sets received.

The team continued to gather data with the goal of beginning data analysis and modeling to develop new emissions factors. The team aimed to have most of the data collected by the end of January 2026. Additional data analysis and modeling work was to commence after data had been collected.

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INTELLIGENT UTILITIES

Developments in this area include the use of advanced data-collection, management, and information technologies to improve the safety, reliability, and efficiency of natural gas operations.

Efforts are being made to develop, commercialize, and implement technologies to automate data collection, reduce manual data entry, enhance data quantity, and reduce data-entry backlogs.

The program is aimed at delivering software, hardware, standards, and procedures to improve the accuracy, consistency, completeness, and relevancy of information and ensure regulatory compliance.

Current efforts include the development of a process visualization and reporting capability, smart phone tools, 3D visualization software, and the development of industry-supported standards for transmission tracking and traceability.

GNSS Consortium 2025

The team will research and share information on GNSS and complementary geospatial technologies that can support daily utility operations.

Project Description

The GNSS Consortium Program researches and shares information on positioning and geospatial technologies that can support utility operations, create operational efficiencies, and improve the quality of field-collected data. While GNSS remains foundational to utility geospatial workflows, the 2025 Consortium reflects a strategic initiative to broaden its focus and evaluate complementary technologies, especially where GNSS faces persistent, known receiver challenges.

The GNSS Consortium began in 2007 to evaluate emerging positioning technologies and share practical findings with participating sponsors. In 2024, the team tested a visual positioning system in dense urban areas and found that camera-based location tools may help support field work where satellite-based positioning can be difficult.

In 2025, the team continued informing project sponsors about the latest innovations and research in GNSS and related geospatial industries while using VPS as a focused example of the broader transition toward evaluating complementary technologies for utility positioning and spatial data workflows.

Deliverables

Deliverables for this project will include a full list of technologies under consideration, technology evaluation reports covering existing literature, accuracy measurements, use cases, costs, and risks, and a Final Report that summarizes and details project accomplishments, includes all results, expands on industry insights, and outlines next steps for the program's continuation.

Benefits

High-accuracy positioning and geospatial record-keeping for assets and operations are essential for utility GIS operations and field data management. Reliable location data can reduce construction and maintenance costs and improve asset management, emergency response, and damage prevention. Because utilities continue to face persistent GNSS receiver and geospatial data challenges, the Consortium will keep sponsors informed about both improvements in GNSS technology and complementary geospatial methods that may strengthen field positioning, mapping, and asset-location confidence.

Technical Concept & Approach

The 2025 GNSS Consortium will evaluate complementary geospatial technologies that may help utilities collect reliable location data where traditional satellite-based positioning is difficult. The work will use visual positioning systems as one example while also considering other tools that could support field mapping, asset records, and future operations.

The team will identify available and emerging technologies, review key information on performance, cost, deployment needs, and risks, and discuss priorities with Consortium sponsors. The final work will summarize which technologies appear most practical for additional evaluation or future utility use.

Results/Status

The team continued studying visual positioning systems, or VPS, because these tools may help utilities collect location information in places where satellite signals can be unreliable, such as dense downtown areas. In 2025, the team selected Immersal for additional testing because its system allowed more customized mapping and field data collection than the platform reviewed in 2024.

The team set up precise reference points at both a campus site and a dense urban area in downtown Chicago. These reference points give the team a reliable way to compare VPS results against known locations and better understand how accurate and consistent the technology is in different settings.

A vendor developed a custom app for the project so the team could collect location data in the field and compare different positioning methods. The app uses camera-based visual references to place users within a map and record location points for evaluation.

The team began collecting and reviewing data to confirm that the custom maps and app were working properly. Initial campus data was collected using both standard map-based positioning and positioning tied to the precise reference points, while initial downtown data was collected to establish a baseline for urban performance.

The 2025 work established a practical test approach for evaluating VPS and other location technologies in the future. Early results are encouraging and suggest that VPS may help support utility field work in areas where satellite-based positioning is difficult, if the remaining analysis confirms that the technology meets accuracy and performance needs.

Remaining work includes finishing downtown data collection, comparing results from both test sites and both positioning methods, and summarizing how well VPS performed. The final analysis will help determine whether VPS is a practical option for utility mapping, surveying, and field data collection.

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Automation of Digital MTR Processing Pilots

This project will provide development support for two pipe mills in the form of consulting and funding for the pipe mill's information technology development resources, and will address the manual methods of reviewing MTR reports for manufacturing specification compliance. Automating this verification will reduce the time needed to check each material test report for compliance and minimize mistaken approvals of non-compliant components.

Project Description

This phase is the final step to market. The project team will assist two pipe manufacturers in developing the process code to automatically populate the test results into the new OTD data transfer template. The team will support modifications for any anomalies found in the data transfer template during this project and will review the results of the pipe mills' IT work to ensure the digital data complies with API 5L reporting requirements for an MTR and the data dictionary presented in API 5L RP-5MT. The team will provide consulting assistance to the manufacturer in labeling pipe with GS1 standard barcode identification and design and build analytical processes for verification of mechanical and chemical test results in a digital MTR report. This work will be developed on the Apple (iOS) platform. This project will develop software to automate this process.

Deliverables

The deliverables of this project will be a fully digital material test report that demonstrates the advantage of the digital MTR report by reducing the manual processes of the PHMSA TVC requirements for line pipe, and a final report detailing the successes and challenges of the project.

Benefits

The adoption of this technology by pipe manufacturing companies will reduce the time needed to verify each material test report for specification compliance and minimize the potential of mistakenly approving a non-compliant component for use due to human error.

Technical Concept & Approach

Specific tasks in this project include:

Pilot Manufacturer Project Development (MTR)

This task includes the design work needed to establish the required infrastructure and introduce the utilities and pipe manufacturers to the digital template used in the prior pilot. The project team will review and answer questions about the structure of the digital MTR template and its data requirements, seek clarification, and resolve several key issues discovered in the development of the template. The team will serve in a consulting capacity to assist the pipe manufacturer in converting current reporting programs as a starting step in the development of the needed scripts to populate the Digital template. The project team will provide a review of the output of the manufacturer's scripts and will assist the manufacturer with a database design for storing the digital MTR for issue as requested by the utility.

Pilot GS1 Marking at Manufacturer's Facilities

This task includes the development of printing processes from data derived from the manufacturer's ERP systems to apply GS1 standard identification that is integrated with its production control system. This will include acquisition of the same data used for proprietary identification to tailor it into a GS1 standard identification using GS1 identification standards and GS1 GDSN services for incorporation of product catalog data into the total track and traceability solution.

Pilot Document Integration (GTI Verification Storage System)

The team will implement a security layer in the publication of the digital MTR, enabling the distribution of the digital MTR without concern for the authenticity of the digital MTR. Once this task is completed, the digital MTR reports can be distributed and copied, recopied, and verified as genuine. This task is the implementation of W3C specification, Decentralized Identifiers (DIDs) v1.0. This task supports open supply chain trading models for secure documentation and addresses all materials traded where two party security measures will not protect

the digital documents from alteration.

Mobile Analysis

This task includes researching the acceptance criteria for chemical and mechanical test results for each type (process of construction) and grade of steel used to manufacture API 5L line pipe. The scoping process will identify early on in the project the criteria for manufacturing pipe for a specific customer and will build the acceptance criteria for chemical and mechanical properties for steel specific to the orders placed for the pilot order(s). The process technology will be designed to accommodate additional steel grades and pipe types but will not convert the entire set of criteria from API 5L for other steel grades and pipe construction types covered in API 5L.

Results/Status

During this project, the project team was invited to join an API working group developing an annex for API RP-5MT to incorporate machine readable identification systems, such as barcodes, RFID, or other digital IDs, for API 5L pipe. The team contributed to the workgroup formed at the API conference to create an addendum to establish a machine readable identification process. A draft annex was submitted for committee review in May 2025. As of the Final Report's publication, a related ballot had been issued in the API ballot portal.

As a result of API comments regarding the inclusion of another standards organization's information in an API standard, a secondary reference manual was developed that provides how-to examples for identifying a transmission component using GS1 standards, including detailed information on GS1 barcode content and examples of using highly detailed product information from the GS1 product information system (GDSN). The manual was not included in the recommended practice but was to be called out as an external document controlled by the interested parties using GS1 standards to identify API 5L pipe.

The utilities were concerned that different identification processes were part of the workgroup's final recommendation. No specific concerns were expressed with transferring digital MTR data using the JSON template developed for the prior OTD project 8.22.c. The utilities in these discussions elected to wait until the workgroup completed its work and issued an amended API 5L RP-5MT for a vote.

The team held several meetings with various proj-



ect sponsors and pipe manufacturers to find potential projects. Although some promising options were identified, the team was unable to secure commitments for a pilot project due to construction rescheduling and other challenges, such as resistance from manufacturers. The team did enable one manufacturer to obtain the necessary GS1 registration, allowing them to generate GS1 based barcodes on pipe already extruded for a pipeline operator. Despite this, the manufacturer did not follow through with creating or placing the 2D barcodes on the steel transmission pipe.

Despite several attempts, including starts and stops, the team was unable to arrange a pilot demonstration with a steel pipe and/or component manufacturer. However, the team made significant progress in securing the use of GS1 based technology through its efforts with the API Working Group.

The next phase of this initiative aims to develop a functional digital catalog and secure two or three project sponsors, along with some of their pipe and fittings providers, to serve as the foundation for the industry wide GS1 based tracking and traceability system.

This project is complete. A Final Report was issued in July 2025.

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Optically Clear Transmission Pipe Coating

Researchers will develop procedures for applying machine readable barcode identification to natural gas transmission components without compromising the coating that protects them from corrosion. Encapsulating the identification in the coating system extends its resilience, permitting reading in the future and limiting the risk of scrapping useful pipe due to loss of traceability information.

Project Description

OTD project number 8.18.a.2 developed a laser engraved barcode for part identification. Existing coatings designed to protect components from corrosion would obscure this marking making it unreadable. This project seeks to develop a coating product and application procedure that protects natural gas transmission components from corrosion and enables the application of machine-readable identification, barcodes.

A second objective is to apply additional identical barcodes at some interval along the length of the pipe under the coating system during the coating process. Duplicate barcodes are applied to support sectioning the pipe one or more times for different construction lengths and store unused pipe segments with confidence that the identification information is available from a simple barcode of the remaining pipe.

Deliverables

The main project deliverables will be a final report that summarizes procedures for transferring data reliably and securely from barcodes on ID of pipe to OD of pipe prior to coating, and an assessment of one or more coating system(s).

Benefits

Identification of piping system components has traditionally used human readable identification, applied through a variety of means with stenciling, printing or metal stamping. In the event of a project being delayed or cancelled, pipe is often resold. This pipe is most likely stored outdoors, and its identification information is often lost due to sun fading the inks, paint from multiple forms of atmospheric attack. Encapsulating a laser engraved identification barcode in the coating system can extend its resilience for reading scanning, permitting reading in the future, and limiting the risk of

scrapping a useful product simply due to loss of track and traceability information.

Technical Concept & Approach

Specific tasks in this project include:

Coating System Development

Conduct discussions with coating system manufacturers for potential candidate coating systems for reformulation. If there are no suitable coating systems then discuss time, schedule, and cost to build a new coating product, test variants of that product creating possible new coatings.

Application procedures, processes, and testing

Work with coating companies and pipe manufacturers to evaluate different protocols for marking the pipe on both the ID and OD and the methods of transferring the content from a scan of a barcode on the ID of the pipe or fitting to the OD. This includes developing a cleaning and laser engraving processes for trial and to ensure integrity for the transfer of the mark from the ID to OD of the component and establishing test environments to perform laboratory development of cleaning, ID laser engraving, barcode copy and transfer processes to carry barcode data to OD.

Results

The project started by looking at several commonly used coating systems that might become clear enough to transfer light if the pigments were removed. The premise was to identify coating systems with optical properties clear enough that would enable the scanning of barcodes engraved into the base metal of the pipe through the clear coating. The project team researched four coating system companies that protect transmission pipe and found no coatings suitable for the initial project scope.

The team started a process to research one of the

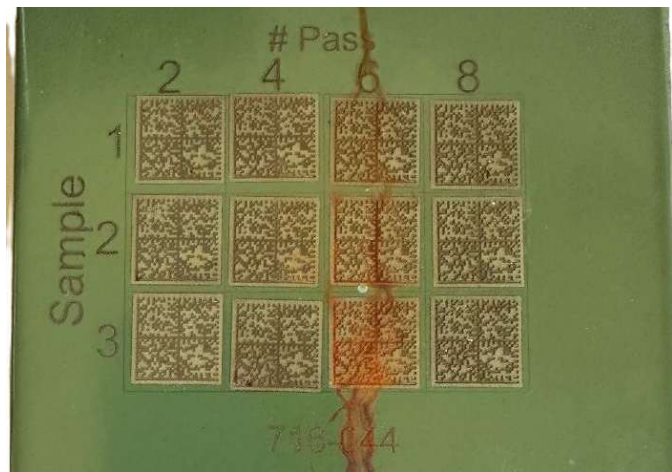
most widely used coating systems with a significant market share, Fusion Bonded Epoxy (FBE). FBE is applied with a significant thickness that engraving it to no more than a depth of one and one-half mils could provide an opportunity for direct part marking transmission pipe. The work yielded a barcode of one and one-half mils that is easily read by an imaging processing technology running on a cell phone, and the barcode is resilient to damage and not easily counterfeited as is the case with identification using labels.

The project team engraved test samples of green and brown FBE coated plates and used a 3D laser profilometer to measure the precise depth of the engraving processes, with a maximum measured depth of 2.3 mils. The 2D barcode engraved in the green FBE test plate was verified to establish a baseline of barcode quality data, and the engraving on the green plate produced the highest score in every category of the ISO 29158 barcode quality evaluation. The direct part marked plates were then subjected to a 100 hour salt fog test to assess the barcodes' resilience to a corrosive environment. The five shallowest barcodes engraved on the plate were reverified after the salt fog exposure, and the verification data showed a significant reduction in quality levels. Several other barcodes verified to similar quality levels; the balance of the barcodes on the test plate failed verification due to the action of the salt fog.

Despite the reduction in scoring, all but three barcodes could be read accurately when scanned with a standard cell phone. The three that could not be scanned were stained with a heavy deposit of rust resulting from improper positioning in the salt fog test chamber.

Based on the test results of this work, the project team used the shallowest engraving parameters to engrave additional test plates in both colors, collecting enough data to publish engraving protocols for this marking process. Production engraving parameters were completed for the green FBE sample, and new protocols were tested for the brown FBE since initial laser settings removed material greater than two mils.

Although no coating was in production that could fulfill the original scope requirement, the project successfully developed engraving procedures that can be applied to an FBE coating system. If a sufficient film thickness of the FBE is applied to the pipe, it can be engraved without concern. The procedures and processes developed also reduce



Initial test plate after salt fog testing

the time needed to establish engraving parameters for FBE products from other vendors.

Status

A follow on project was recommended to develop a cover material for protecting barcodes engraved in FBE, applied directly after engraving to prevent degradation of the barcode when exposed to weathering and to restore the coating thickness reduced by the engraving process. Where specifying additional coating thickness at the time of order is not feasible, candidate approaches include a clear repair product, an abrasion resistant overlay (ARO) system, a tape applied repair, or a machine applied, UV cured seal, most likely applied with automatic (robotic) technology.

This project is complete. A Final Report was issued in May 2025.

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Developing Routing Solution for Leak Survey

The team will refine a GIS based leak detection task application, working with a technology partner to make multi-stop route optimization accurate on mobile devices and to add user tracking (breadcrumbing) with visual cues of task completion. This will help field crews complete leak surveys at the correct locations and verify that no tasks have been missed, increasing public safety and strengthening an operator's integrity management program.

Project Description

This project will continue to refine the leak detection task application developed with a technology partner in Phase 1. The team will work with the technology partner to make multi-stop route optimization functionally accurate on mobile devices, to add user tracking (breadcrumbing) with visual cues of task completion, and to enable live route editing so survey crews can adjust their route and stops while out surveying.

Deliverables

Deliverables for this project include the refined leak detection task application, with accurate multi-stop routing and route optimization on mobile devices, live route editing so survey crews can adjust their route and stops while out surveying and be re-routed, user tracking (breadcrumbing), and visual cues of task completion. The project also delivers a pilot demonstration of the application within a project sponsor's operational footprint.

Benefits

Field personnel conducting leak surveys can benefit from a GIS based solution that provides optimal routes to multiple leak detection sites, while tracking the completion status of tasks and the paths taken to each task. Efficient scheduling and routing will help field employees complete leak

surveys in the correct locations. This unburdens field personnel who can instead focus on safe driving and performing the leak detection tasks at hand. With the added functionality of task management and 'breadcrumbing' between leak detection tasks, work completion can be tracked and verified. It assures that no tasks have been missed, which increases public safety and strengthens an operator's integrity management program.

Technical Concept & Approach

Building on the Phase 1 work with the technology partner, the team will refine the application so that multi-stop routing and route optimization are functional and accurate on user mobile devices, integrate user tracking (breadcrumbing) with visual cues that inform the user when all leak detection tasks are complete, and enable live route editing so survey crews can adjust their route and stops and be re-routed based on efficiency and surveyor needs.

The team will conduct robust testing of the application to ensure it is ready for use.

The team will then conduct a pilot demonstration of the application within a project sponsor's operational footprint, assessing how well it can become part of an operator's current workflow and how easily it integrates with an operator's existing technologies and systems of record.

Results/Status

The project team and the technology partner have agreed on the project scope and who is responsible for each part of the work. The technology partner has outlined the main pieces of the final solution, including mapping, live location tracking, digital forms, automated scheduling and notifications, repair-related work orders, reporting, and additional information that could help operators better understand field conditions.

The technology partner shared the project progress at the OTD Fall meeting and demonstrated the platform for sponsors. The project team also held user experience meetings with sponsors and technical representatives to better understand what utilities need in the field. Some features are ready for review, including audit tracking and corrective action management. Other features, such as breadcrumbing and asset-based routing, are still being developed. Breadcrumbing needs to be moved from the older app into the new app, and asset-based routing is still being reviewed to make sure it meets the project scope. The guided tour and reference guide were also updated with input from the project team and technology partner.

The sponsor discussions helped the team understand how leak surveys are actually performed. One utility uses tablets for walking surveys, completes about 19 to 25 leak surveys per day, uploads monthly leak survey maps, and relies on a GIS mapping system to view asset information. Another utility explained that survey routes often change based on access in the field. Surveyors may complete one side of a street and then return on

the other side, or divide a larger area into separate grids. Sponsors noted that assigning each surveyor a clear work area could help avoid confusion. They also emphasized the importance of accurate GIS location information so assets are surveyed correctly and work completion can be verified.

These findings were shared with the sponsors during a second round of discussions. After the technology partner completes the next set of application updates, the project team will begin testing the platform, similar to the testing completed in Phase 1.

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Ground Cover Change Detection for Transmission Pipelines

Researchers will identify cost-effective proximity and remote sensing technologies to monitor transmission pipelines for potential threats and ground cover changes. This gives operators a more efficient, lower cost way to monitor pipelines and extends coverage to remote, otherwise inaccessible areas.

Project Description

8.23.k Ground Cover Change Detection for Transmission Pipelines supports pipeline operator monitoring and inspection compliance efforts. Though operator monitoring programs vary in terms of frequency and other details, they generally require costly, intensive and frequent monitoring efforts by field staff to identify unreported threats that require further investigation.

Maintaining pipeline infrastructure includes understanding and monitoring risks to that infrastructure, especially assets with above-average likelihood and/or high consequence of failure. For some operators, monitoring infrastructure includes driving many miles of pipe each day to detect changes or threats. Further complicating these efforts, many operators have vast territories with many assets located in remote areas, which makes frequent, consistent monitoring challenging.

To address both challenges, the project will pursue monitoring solutions for two distinct, but interrelated use cases: (1) proximity sensing, to augment and complement monitoring in discrete areas and full corridors, and (2) remote sensing, to identify threats to assets in remote areas. The technology search will be limited to commercially available and open-source technologies, best practices, and methodologies readily available as turnkey solutions.

Deliverables

The deliverables from this project include lab test results, pilot test results, and a final report.

Benefits

Monitoring pipelines, especially critical infrastructure like transmission pipelines, can be time-consuming and expensive. Through the application of modern technologies and processes, there exist opportunities to improve the efficiency of this task and potentially identify threats that would otherwise go unseen. Identifying processes that simplify and improve monitoring activities will improve safety, reliability, and cost-effectiveness of operations.

Technical Concept & Approach

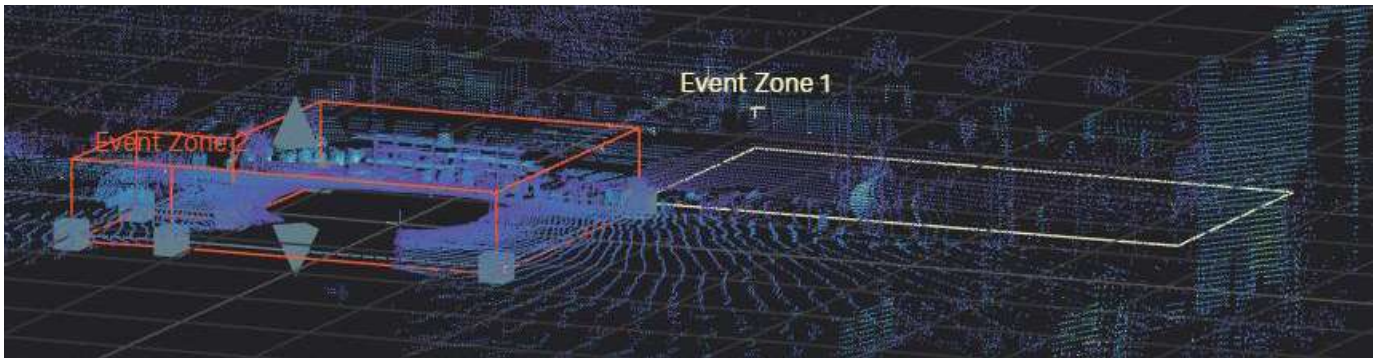
Specific tasks in this project include:

Background and Product Review

GTI Energy selected LiDAR sensors and software for the proximity monitoring use case, and high resolution satellite imagery for the remote sensing use case. For proximity sensing, conditions of interest include steel plates, sinkholes and potholes, uneven asphalt (such as serrated or milled pavement), excavation activities, and active traffic sites. For remote sensing, conditions of interest include significant ground coverage change and land movement events (such as landslides), excavation activities, and construction.

Lab Testing

Lab testing for this project focused on testing the LiDAR and satellite imagery technologies in a controlled environment. The team's experiment design evaluated two LiDAR deployment methods: a stationary pole-mount application and a mobile vehicle-mount application, to detect conditions of interest.



A screenshot of the two zones at an angle to demonstrate the ability to add height.

Pilot Demonstrations

The pilot demonstration focused on identifying ground-cover change related to landslide events using high-resolution satellite imagery.

Results

The project looked at two monitoring methods: satellite imagery with GIS tools for remote areas, and LiDAR for closer, on-site monitoring. Both methods showed useful benefits, including flexibility, reasonable cost, repeatable use, and the ability to support ongoing monitoring after setup and adjustment.

Proximity Monitoring and Sensing: Pole Mount

The team tested a pole-mounted LiDAR sensor that collected 3D data from two event zones over three-and-a-half weeks. The test recorded almost 1,400 events. The system was able to collect useful information, but it is not ready to use as a standard monitoring tool for the conditions sponsors identified. At this stage, it appears better suited for security applications, though it may continue to improve over time.

Proximity Monitoring and Sensing: Vehicle Mount

The team also tested a vehicle-mounted LiDAR approach using the same sensor and a visualization platform. This setup can collect and display 3D data, but it does not currently have a real-time tool to automatically identify objects. Visual review showed that the approach may help operators better detect and monitor nearby right-of-way threats, especially near sensitive underground assets.

Remote Sensing

The team tested GIS methods in combination with high-resolution satellite imagery for the remote use case. GIS methods successfully identified excava-

tion and construction and showcased the flexibility of on-demand high-resolution satellite imagery for wider remote monitoring applications. This approach is by far the most affordable and reproducible the team considered during market research for remote sensing. The satellite imagery service can be deployed on demand to anywhere in the world multiple times a day if needed, giving operators flexibility to determine monitoring frequency. In combination with GIS methods, operators could monitor wide areas for a variety of threats, ranging from excavation and large-scale construction to landslides, with the opportunity to develop methods using historical data and to iteratively improve models over time.

Pilot Demonstration

The pilot demonstration focused on using satellite imagery to monitor ground-cover changes related to landslides. The results showed that GIS methods can help identify conditions of interest and can be scaled to support different operator monitoring needs.

Status

Although the proximity and remote sensing use cases were tested separately, they could be used together to support a more complete monitoring approach. Future research could further refine both methods by developing models that address specific utility needs and by improving how the remote and proximity tools work together. This project is complete. A Final Report was issued in July 2025.

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AI for Field Operations

Researchers will develop computer vision models to identify and classify rust on utility meter sets, isolating meter set components and using generative AI to synthesize training imagery that improves model accuracy. This work will help utilities improve field data collection, prioritize asset maintenance, extend asset lifespans, and reduce part replacement costs.

Project Description

Corrosion control and field maintenance for utility assets are essential activities with significant regulatory, safety, and cost implications, especially for meter sets. Data collection by field workers is also of paramount importance to monitor and manage risks and increase asset lifespan. The first phase of AI for Field Operations showed that computer vision can accurately detect and classify rust severity. Phase 2 aims to enhance field data collection, prioritize maintenance for longer asset life and cost savings, and streamline modeling workflows for efficient field data capture.

Deliverables

Deliverables for this project include meter set parts isolation models, a generative AI synthesized dataset of meter sets with labeled corrosion severity levels, retrained computer vision classification and instance segmentation models, a tested workflow integrating the parts isolation model with the classification and segmentation models, a commercialization plan, and a Final Report.

Benefits

The benefits of computer vision models to identify rust include improvement of field data collection; informed asset maintenance prioritization and asset lifespan increases; cost savings on part replacements; and improved workflow, accuracy, and efficiency for fieldwork.

Technical Concept & Approach

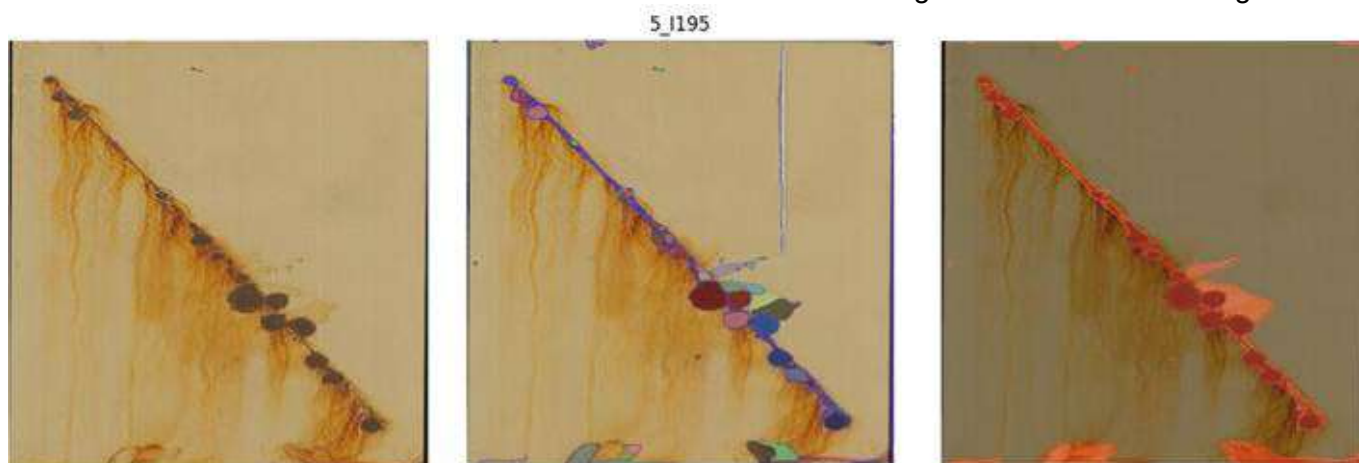
Specific tasks in this project include:

Meter Set Parts Isolation Modeling

The work in this task will focus on developing models and approaches to isolate and label meter set parts within images of Meter Set Assemblies (MSA's). The team will evaluate various methods and open-source models to isolate MSA's within images, and then subsequently pursue isolation and labelling of specific components within images of MSA's.

Generative AI for Synthesis

The work in this task will focus on testing Generative AI diffusion models to create a novel, useful dataset of MSA's characterized by distinct (labeled) levels of corrosion, for inclusion in classification and instance segmentation model training.



Original image; Middle: Output from SAM2 model showing individual masks identified; Last: OpenAI labelled masks that it qualified as rust.



Result of Azure background removal

Computer Vision Models Re-Training + Modeling Workflow Testing

The team will re-train models completed as part of AI for Field Ops, Phase I, with the supplemental imagery created as part of the Generative AI for Synthesis task. The team will design and test a workflow for classification and instance segmentation computer vision models with the meter set parts isolation model developed on previous task.

Commercialization and Implementation

The team will create a commercialization plan to deploy MSA models for field usage, both for corrosion detection and other purposes. The project team will conduct market research and consult with interested parties on product access, design, and testing.

Results/Status

AI for Field Operations Phase 2 refined AI models to accurately segment and isolate meter set components, remove background noise, and improve the identification of corrosion and rust. The project team finalized and implemented an experimental image segmentation and labeling workflow and then scaled it to generalize across the full set of training data.

The workflow integrated Segment Anything Model (SAM 2) segmentation, GPT-4 zero-shot classification, and a custom U-Net model to isolate and assess relevant components in complex scenes. SAM 2 segmentation masks were used to isolate lab created rust in the training data, a zero-shot general model performed mask labeling, and a human-in-the-loop review ensured correct labels, iter-

atively refining both the segmentation and labeling components before the model was trained on the labeled data. In Phase 1, labeling consumed hours of labor; the new approach reduced that labor and refocused efforts on model fine-tuning and review rather than painstaking instance segmentation labeling, while also producing far more accurate instance segmentation results.

This computational approach to data labeling and annotation produced an estimated 90% reduction in the cost and time spent on labeling compared with the hand labeling done in Phase 1. The re-trained computer vision models, based on a U-Net architecture, performed more than twice as well as the Phase 1 models. By filtering out irrelevant elements and narrowing the analysis to high confidence segments, the workflow significantly reduced false positives compared to earlier phases, correctly excluding non meter set and non utility objects such as classic cars. The U-Net assessment of GPT-4-vetted segments confirmed that corrosion could be characterized with improved precision, reducing the risk of incorrectly evaluating regions of input images.

Some challenges remained at each stage of the workflow, including ambiguity in macro images that lacked broader context, along with sensitivities around sharp edges and environmental factors. Even so, the combined approach demonstrated cohesive, high performance and offered notable improvements in accuracy, modularity, and generalization, marking a considerable advance in component level condition assessment.

Recommended future work centers on continued refinement and fine-tuning of the workflow, particularly in handling edge cases and improving context awareness to further enhance model precision and reliability. With continued development, this methodology holds potential for scalable deployment in corrosion detection and similar object level assessment tasks.

This project is complete. A Final Report was issued in July 2025.

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Data Driven Investigation of Inspection Intervals

This project's objective is to examine the frequency of inspection intervals by analyzing and modeling operator data, which has the potential to save utilities time and money.

Project Description

Local distribution operators are subject to federal, state, and local regulations requiring the regular inspection of distribution infrastructure. Although these patrols and surveys are paramount to maintaining safety, they are also resource intensive, requiring ground crews to walk hundreds of miles of pipeline and thousands of service lines and meters. New technologies, such as advanced mobile leak detection, have provided solutions to improve overall system monitoring and supplement these walking surveys. Furthermore, infrastructure characteristics, such as the age and material type of pipelines, can help explain differences in leak rates and other pipeline failures. These new monitoring technologies and infrastructure knowledge provide a means to use data to inform inspection intervals.

Deliverables

The deliverables for this project include an analysis of operator data to evaluate the best inspection intervals, identification of appropriate safety and risk metrics, a model of those metrics, and a final presentation and report.

Benefits

Operators have limited resources to conduct infrastructure inspections. There is an opportunity to use operator data to substantiate inspection intervals and investigate the possibility of less frequent monitoring and utilization of multi-modal inspection techniques. Inspection intervals that are informed by data have the potential to save utilities time and money.

Technical Concept & Approach

Specific tasks in this project include:

Identification of metrics and data sources

This task will involve working with sponsors to identify the metrics that can be used to substantiate inspection intervals, such as risk, integrity, and safety metrics. After identifying these outcome metrics, the team will work with sponsors to identify data streams that can be used to quantify those metrics and data that can be used to predict or explain those metrics. These data could include the results of past inspections, customer leak reports, leak tickets, failure data, repair data, or other monitoring (e.g., AMLD) results.

Data management and cleaning

This task will involve collecting, storing, and cleaning data for data analysis. After the relevant data have been identified, this task will focus on gathering and securely storing the data. The data will then be merged, cleaned, and otherwise quality controlled to ensure reliable modeling results.

Model development and data analysis

The team will identify and develop appropriate statistical methods that can be used to model the outcomes. This task will involve the execution of the developed models to analyze the data, check modeling assumptions, and generate tables and graphics.

Results/Status

The team completed data collection from project sponsors, securing leak survey data and geographic information system (GIS) data from two operators. One operator provided multiple years of leak survey data from its entire system, offering a system level view of leak discovery across multiple years. The data provides leak grades, material type, and information about the time to repair. The second operator provided single year walking survey results that include counts of assets surveyed regardless of whether a leak was discovered, with leaks attributed to one of three categories (main, service, or meter), along with GIS data on its assets in one service territory. The team cleaned and processed these data sets and identified the important advantages and limitations of each. Because each data set has limitations for investigating the relationship between inspection intervals and leak discovery, the team identified a pathway for using features from each data set to inform the creation of a local distribution system emulator. The team processed the GIS data to create survey grids that summarize the assets within each grid. This processing removed specific georeferenced information to create an anonymized system representation for use in model development.

The team proposed a leak birth, discovery, and removal (BDR) model that utilizes the sponsor provided data to achieve the project's objectives and began developing it. This project focuses primarily on the leak birth and discovery components of the BDR process. The birth component simulates new leaks developing stochastically in the system, accounting for the effects of pipeline material and vintage; the discovery component models leak surveys, focusing on walking surveys for this project; and the removal process reflects how leaks are taken out of the system through repair or replace-

ment. An important feature of the BDR model is the ability to specify a leak survey interval and examine the effects of that interval on the discovery of leaks. For example, the user can specify that the entire system be surveyed every year or every 5 years. The emulator tracks features such as total undiscovered leaks, equivalent leaks (i.e., leak-year equivalents), and counts of undiscovered leaks of different grades to understand the impacts of different inspection intervals.

The team proposed steps to develop and implement the BDR emulator: characterizing the system infrastructure on a gridded scale by type, age, and pipe material; stochastically simulating the birth of leaks while accounting for infrastructure properties and known differences in leak occurrence by material and age; stochastically simulating the discovery of leaks using knowledge of leak survey methods; and tracking the removal of leaks based on repair times for leaks of different grades. These steps are repeated at a desired time scale for the desired period. Recognizing overlap in project needs, the team is coordinating with a related OTD project (ALDP Tiered Surveys) to develop the BDR model. This project focuses on walking surveys while the related project considers advanced leak detection methods such as mobile or satellite surveys. The team is working to address several implementation challenges associated with the BDR model, including the appropriate spatial and temporal scale for modeling the birth and discovery process, the trade-offs of creating a generic versus a specific local distribution system, and incorporating costs and practical survey considerations into the model.

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Identifying Functional Issues with High Frequency AMI Reads

Researchers will analyze high frequency AMI data to develop methods that identify anomalies and detect abnormal gas usage. This enables utilities to respond more quickly to issues such as leaks, equipment failures, and theft, improving the safety of local distribution systems.

Project Description

This project will analyze high frequency AMI meter readings to develop methods to identify anomalies. These anomalies may be due to tampering, theft, equipment failure, leaks, or unusual customer behavior. Using data from high-frequency meter readings and incidents of anomalies, this project will develop and apply statistical techniques for analyzing the data to identify these upset conditions. These techniques may include statistical machine learning or pattern recognition approaches.

Deliverables

The developed approaches will be documented in a final report that will include analysis results, challenges of analysis, and areas of future work. Algorithms and analysis approaches will be available to sponsors via code sharing.

Benefits

Smart meters and high frequency meter readings produce large volumes of data that can enable the detection of tampering, theft, failure states, or other anomalies. Identifying these features can save utilities and customers money and improve the safety of local distribution systems.

Technical Concept & Approach

Identification of data sources and data management

This task will identify the high-frequency AMI data and the associated information (e.g., customer information, spatial location) provided by sponsors that will be used to develop the analysis approach. This task will also include data management to ensure secure transfer, storage, and access.

Data cleaning and processing

This task will involve preparing the data for analysis. After the data have been transferred and stored, this task will focus on preparing the data for analysis by performing data quality checks and exploratory analyses. This step will involve removing or correcting data as needed, merging data sets, creating training and test splits, and otherwise quality controlling to ensure reliable modeling results.

Model development and data analysis

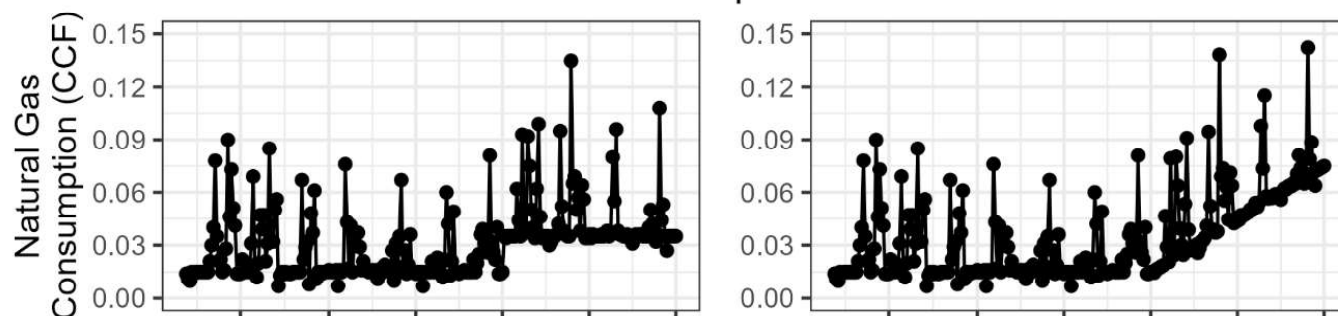
In this task the team will identify and develop appropriate statistical methods that can be used to model the outcomes. This task will involve the execution of the developed models to analyze the data, check modeling assumptions, and generate tables and graphics.

Results/Status

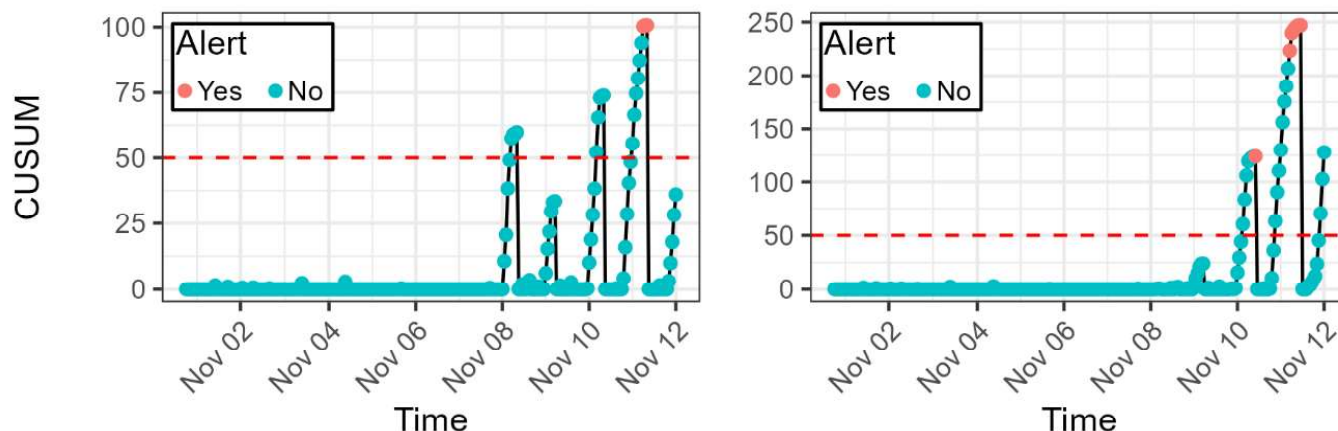
The project team first looked at how three existing AMI analytics programs operated by local distribution companies (LDCs). The LDCs said these programs are helpful because they can improve safety and customer service. Each utility used different rules for when an alert should be created, but all reported that the data helped them find and address potential issues in the field.

The interviews helped the project team understand what a useful detection tool needs to do. First, utilities need to be able to adjust how sensitive the tool is so it does not create too many or too few alerts. Second, the tool should compare a customer's current gas use against that same customer's normal usage pattern. The team focused on two types of unusual gas use: a small increase that continues over time, which could point to something like a valve left slightly open or a hot water leak, and a

Simulated Anomalous Consumption from Real Customer



Cumulative Sum of Time Series with Alerts



sudden large increase that could point to a more serious problem, such as a major leak.

The team then tested the approach using customer meter data from two utilities. They developed a method that looks for changes in a customer's gas use over time and flags patterns that appear unusual. The team tested this method on about 4,200 customers and compared it with a simpler approach that creates an alert when hourly gas use continues for four days. The simpler approach created 220 alerts. The new method created 208 alerts, and 120 customers were flagged by both approaches. The team also checked whether the method could find examples that field crews had already confirmed as real issues. For the small group of 16 confirmed cases available for review, the method identified the problem and created alerts in the weeks before the issue was officially reported.

The team also built a sample dashboard to show the results in a practical way. The dashboard lists customers with unusual gas use, lets users view each customer's usage pattern, shows recent data from the last 24 hours, ranks alerts by seriousness, and tracks how long an alert has been active so utilities can focus on problems that continue over time.

Status

This project is complete, and the final report was issued in June 2025. Future work could focus on making the dashboard easier for utility staff to use, improving the detection method with more customer history, seasonal patterns, weather data, and vacancy information, and reviewing more field-confirmed cases to build confidence before broader use.

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Identifying Functional Issues with High Frequency AMI Reads

Researchers will refine high-frequency AMI anomaly detection methods and improve the workflow for sharing analytical results with utility operations teams. These advancements will help utilities detect customer usage anomalies more accurately, reduce false positives, and integrate actionable information into operational workflows to improve safety and efficiency.

Project Description

Phase 2 of this project aims to build upon the findings from Phase 1 by improving high-frequency AMI anomaly detection methods and enhancing the workflow for sharing analytical results with utility operations. The project will continue to improve data analysis methods and document shared learning, best practices, and lessons learned for AMI analytics. The scope includes refining anomaly analysis outputs to include information such as meter size, overall customer usage, and alert severity.

Deliverables

Deliverables for this project include an improved anomaly detection algorithm and a refined methodology for integrating high-frequency AMI analysis output into utility workflows. A proof-of-concept anomaly alert dashboard will be developed. The algorithm and workflow will be documented in a final report identifying challenges and implementation strategies, with pseudo-code and code sharing available to sponsors.

Benefits

Smart meters and high-frequency meter readings produce large volumes of data that can improve

gas operations by enabling detection of tampering, theft, failure states, unanticipated consumption, and other anomalies. Identifying these features can save utilities and customers money and improve the safety and efficiency of local distribution systems. As AMI deployments scale, sharing learnings and best practices for AMI analytics and workflows will be critical to capture the potential benefits of these systems.

Technical Concept & Approach

Phase 2 will continue to advance the AMI analytical techniques and workflows developed in Phase 1. The analytical improvements focus on reducing false-positive alerts by incorporating weather data to account for seasonal variations and temperature-driven changes in consumption. The team will also validate the algorithm using ground truth data collected from field crew investigations of alerts. Additional improvements may include adjusting sensitivity thresholds, incorporating meter size and customer-specific information, and evaluating machine learning techniques as potential enhancements to the current statistical methods.

Alongside analytical refinements, the team will continue engaging with operators, subject matter experts, and industry stakeholders including those

Anomalous Consumption Analytics Dashboard



Select Date:

Run

Select User ID:

Summary Users

Users Analyzed and Alerts Triggered:

Total number of users analyzed: 10

Count of consumers that had no or incomplete data: 5

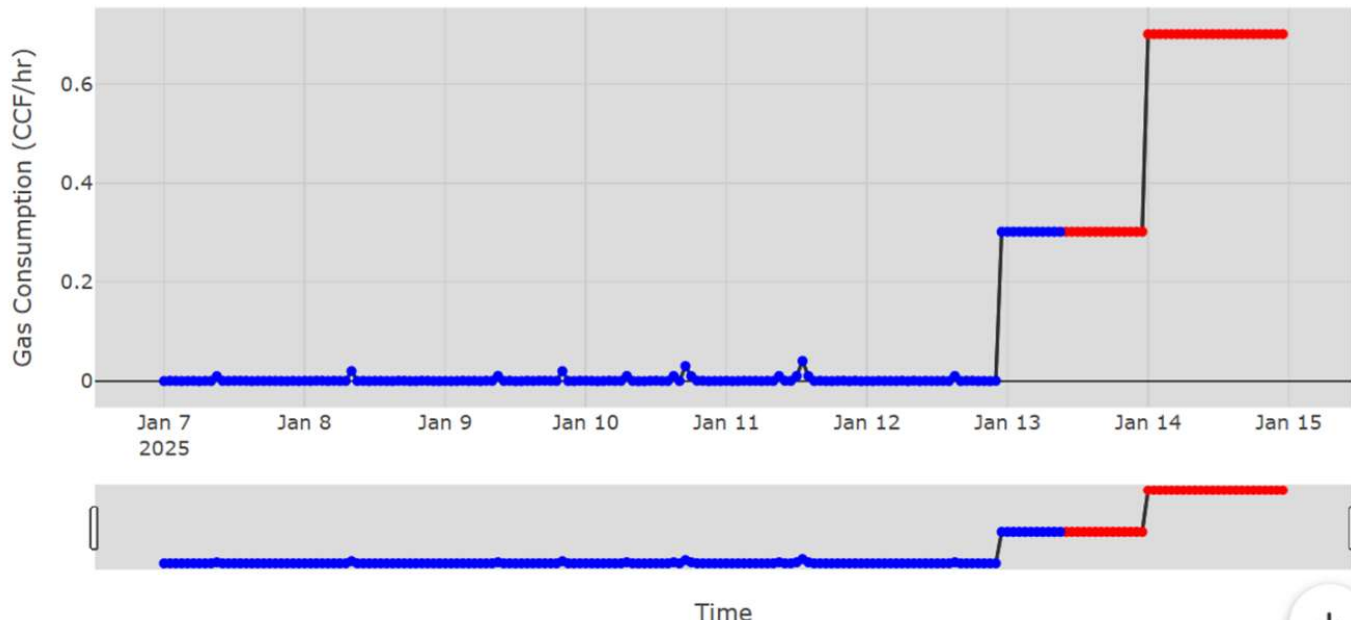
Number of users who had an anomalous reading flagged in the last 24 hours: 3

Show entries

Search:

Ranking	User ID	Severity	Consecutive Days with Alerts	Meter Size	Occupied Residence
1	3204747	High (698x Larger)	1	250	Yes
2	2976687	High (301x Larger)	2	250	Yes
3	3168948	Medium (81x Larger)	2	250	Yes

Gas Levels Over Time with Alert Status



with established anomaly detection workflows to gather requirements and inform algorithm development. These engagements will guide how analytical results are communicated to operations teams, including tuning the number of daily alerts, incorporating ancillary information such as alert severity and overall customer usage, and improving overall workflow integration. Scalability of analytics across large customer bases is also a consideration, given the computational demands of hourly or 15-minute-resolution data.

Results/Status

The team developed and deployed the Consumption Anomaly Surveillance Tool (CAST) dashboard, available at <https://cast.gti.energy>, with a landing page and supporting how-to video. The dashboard was demonstrated to multiple sponsors, several of whom tested the tool and provided direct feedback; feedback informed minor updates to the dashboard and accompanying materials. The anomaly detection algorithm was modified to accept daily gas usage data in addition to hourly readings, improving usability for sponsors who do not collect hourly data. A comparison of anomaly detection for hourly versus daily data found that hourly data enables detection of anomalies that may not appear in daily data due to increased temporal resolution with hourly data, there are effectively 24 opportunities to raise an alarm each day versus only one with daily data.

Time

Sensitivity testing of key CUSUM parameters was conducted using sponsor-provided data to demonstrate how parameter selection influences alert generation. Analysis using heating degree days identified a subset of customers most responsive to HDD, primarily in the 250-asset class category. One sponsor contributed a supplemental dataset containing a range of meter sizes across residential and non-residential customer classes, expanding the range of operating conditions represented in the analytics. The team also developed a sample AMI usage report to illustrate how customer-level consumption data could be presented for billing-related applications, and explored the potential of indoor methane detector data as ground truth for validating CUSUM-based detection approaches.

Sponsor engagement throughout the project guided dashboard refinement and identified additional use cases, including energy efficiency programs, system planning, predictive billing, and consumption dashboards for customers. A major limitation was the inability to obtain field-validated upset condition data, which prevented training a more complex model for identifying anomalies.

This project is complete. A Final Report was issued in June 2026.

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Automated Field Personnel Training for Utilities

Researchers will investigate the commercial viability of AI tools that securely retrieve information from domain-specific documents and answer text, image, and speech queries from gas industry personnel. This gives field staff instant access to training that supports safe and efficient field operations.

Project Description

The utility industry is experiencing a change in the workforce and seeing higher attrition rates among relatively new employees. Additionally, there is often a time lag between hire dates and when there are openings in training facilities. As such, this project will identify and investigate use cases for AI training, data to include in the training catalog, and test data/application accessibility.

Deliverables

The deliverables for this project include an investigation of use cases for AI training, data to include in the training catalog, a tested application, and a final report.

Benefits

The tool developed through this project will help expedite training of new personnel on how to perform work tasks and field activities quickly and effectively. This AI tool may help provide instant access to a company's procedures, best practices, industry standards, and other useful materials and processes.

Technical Concept & Approach

Specific tasks in this project include:

Use Case Analysis

This task will focus on an investigation of the best uses for AI within gas companies. Understanding use cases will define both the input data required to develop AI assistants and the UI needed to access the output data. The initial use cases will focus on the technical training of field personnel and gas engineers, while other use cases include delivering detailed information directly to field service personnel who encounter an unfamiliar component or con-

figuration, or as a knowledge base for live technical support teams.

Data Source Identification & AI Configuration

This task will ensure data security and compliance by depending solely on provided data and mitigating risks associated with open internet-based solutions. To this end, a comprehensive system for the curation, cataloging, and maintenance of training data will be developed to manage input data and validate output.

Data/Application Accessibility

This task will focus on the requirement of easy access and usability as a prerequisite for any successful AI implementation. Empowering employees with easy access to relevant and up-to-date data and training materials should not only enhance efficiency and safety but also foster a culture of continuous learning and skill development within the organization. While a text-based chat window is the basic UI for AI and related systems, the accessibility of the output will determine its usefulness in everyday business processes. In addition to custom-coded implementation of the AI, the project team will also develop the application so that future APIs can be developed to enable implementations of this functionality into existing applications. Data security will be evaluated and tested at each step.

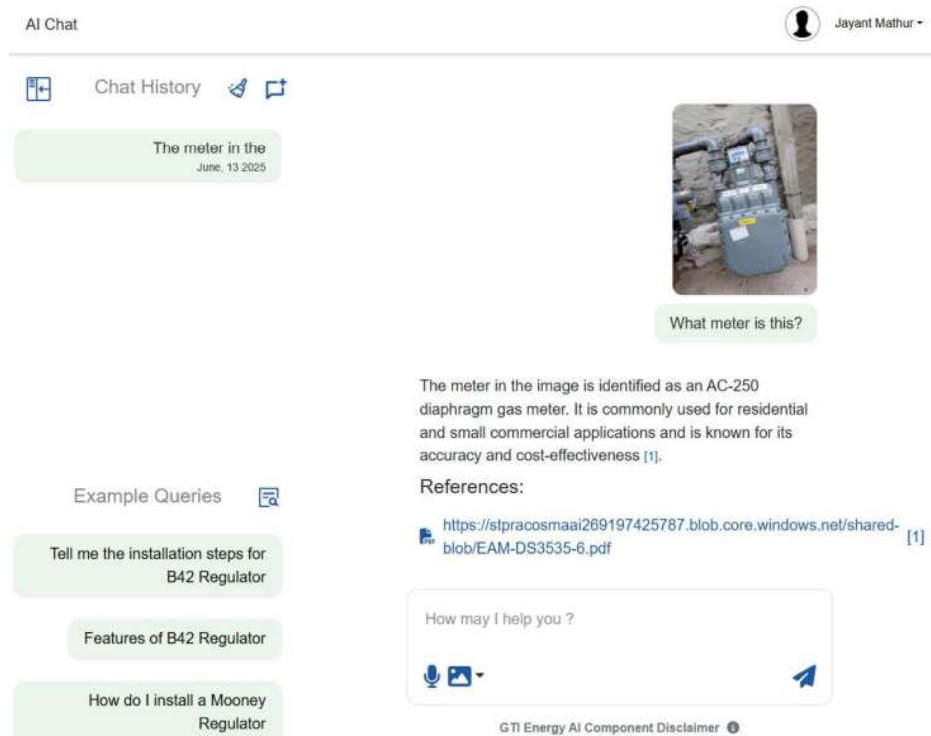
Results/Status

The project investigated how artificial intelligence, particularly large language models and computer vision, could be harnessed to deliver commercial solutions for automated training. These solutions were designed to provide real-time, accessible, and contextually relevant training and support to utility personnel in the field, addressing the widening gap between workforce turnover and the availability of

effective, scalable training.

The core of the work was the development of an AI-powered platform capable of analyzing documented information and interpreting and responding to user queries through text, speech, and image inputs. The platform was tailored to serve a diverse range of users, from novices seeking foundational knowledge to experienced field operators needing quick access to specific standards or procedures. The platform's ability to deliver responses in both text and speech formats makes it especially valuable for hands-free or low-visibility environments, enhancing accessibility and safety in the field. A curated library of over 100 documents, including federal codes, industry standards, and manufacturer specifications, formed the knowledge base for the AI; these documents were selected for their relevance, accuracy, and importance to utility operations. The platform's architecture was built for scalable and secure access and management of documents, allowing organizations to update and maintain their own knowledge bases for the AI to reference, with configurable access controls so that companies can manage documents and user accounts securely.

The platform was driven by Retrieval-Augmented Generation, a technique that grounds AI responses in specific, validated documents rather than relying solely on pre-trained knowledge. This approach significantly improved the relevance and traceability of the AI's answers, allowing users to verify information and build trust in the system, and was supported by a structured pre-query and post-query processing framework that optimizes information retrieval and streamlines response generation. The platform also incorporated advanced prompt engineering to further refine the quality of responses, especially for complex or domain-specific queries. The solution was deployed using enterprise cloud AI services, including a commercial large language model, which provided a robust and scalable deployment.



Testing showed that the platform performed well across a variety of scenarios. It delivered accurate and concise responses in most cases, with an average response time of 9 seconds. Some limitations were noted, particularly in handling image-based queries and complex reasoning tasks, but the overall performance demonstrated the platform's potential as a commercial training and support tool. The platform's multi-modal capabilities and enterprise-level architecture enable scalability, usability, and resilient performance under a variety of conditions, making complex information more accessible and actionable so that field personnel can make informed decisions quickly.

The results establish a starting point for a broader effort toward a comprehensive Intelligent Tutoring System for the utility sector, which could include AI-powered user analytics, personalized learning paths, and adaptive, instructor-curated content delivery. Feedback from project sponsors will be essential in shaping future improvements and expanding the platform's capabilities.

This project is complete. A Final Report was issued in July 2025.

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Center for Applied LDC AI Research

This program helps utilities understand and gain value from rapidly developing artificial intelligence (AI) tools for local distribution company business and operations. The program researches opportunities presented by these technologies, including potential cost savings, and examines the challenges and risks of integrating them into day-to-day operations. This work supports the development of guidance for maximizing the value of AI tools.

Project Description

This program helps sponsors better understand and leverage value from the rapidly developing artificial intelligence (AI) tools. The latest surge of generative AI products based on Large Language Models (LLMs) continues to develop and mature rapidly. These technologies present risks to organizations such as misinformation, unintended consequences, and privacy concerns. However, these same technologies promise tremendous benefits, such as increased productivity, workforce development, and reduced costs. This program researches what is required to protect operators from AI threats and develop guidance for leveraging value. This project is designed to be flexible and adaptive to sponsor's needs; also, the content and topics of focus are adaptable to changes in the rapidly developing AI technology space.

Deliverables

The project consists of three main tasks: technology market research keeping atop the latest AI developments relevant for distribution companies and the energy industry, benchmarking the performance of generative AI tools against gas industry certification and qualification testing, and conducting a live, real world demonstrations of AI's capabilities. Results will be documented in a final report.

Benefits

The research produced by this program will inform gas operators on the latest AI tools, while identifying prime use cases where AI can be applied to improve business efficiency, safety, reliability, and regulatory compliance.

Technical Concept & Approach

Specific tasks in this project include:

Program Scoping

This task identifies the needs of funding members, including determining specific questions and current uses of stakeholders regarding generative AI. The project team conducts market research, gathering information on the recent technological breakthroughs, as well as commercial AI tools designed particularly for natural gas operators. The scoping task provides a solid foundation for understanding the needs, value propositions, and risk management opportunities available to the project stakeholders and will ultimately define the direction and focus of this research center.

Performance Benchmarking

Benchmarking is a technique used in the software industry to measure a system's performance and quantify improvements in new software versions or compare competing products. Generative AI tools, such as popular large language models including ChatGPT and Microsoft Copilot, are often benchmarked against tests, such as SATs, ACTs, and the Bar Exam, to compare the software's performance against humans. The team is instead benchmarking these common tools against gas industry certification and qualification tests to assess these tools' industry-specific knowledge. These benchmarks will create a quantitative measure of whether the fast-maturing AI tools are ready for use in distribution company operations.

Real World Demonstration

This task demonstrates the use of AI for everyday activities relevant to OTD member company operations in a live webinar format, allowing member companies to ask questions and gain full understanding of state-of-the-art tools' abilities. The topics of these demonstrations range from prompt



Screenshot of demonstration on using generative AI tools for data visualization. The image above shows the results from the 3D Maps tool within Microsoft Excel.

engineering large language models to using generative AI tools for data visualization and processing.

Results

The team developed a series of newsletters to track the fast-evolving landscape of AI tools and their implications for the gas industry. These newsletters aimed to provide timely updates on notable milestones in the tech industry, emerging risks, and new opportunities. The 2024 newsletter overall highlighted the increase in electricity consumption attributed to AI and the role of AI in predicting geohazards, noting that AI models outperform traditional methods in forecasting natural disasters. The 2025 newsletters discussed the unified Microsoft Copilot interface for all generative AI tasks, the key relevant facts about the unveiling of DeepSeek (a popular AI-driven app), and a chatbot created to associate third-party methane emissions detections to natural gas producers. The research was sourced from a diverse collection of publications and media.

The team also conducted live demonstrations of state-of-the-art generative AI tools, such as ChatGPT and Microsoft's Copilot. Through these demonstrations, the team educated sponsors on the fundamentals of generative AI, the power of prompt engineering for LLMs, and the capabilities of these tools for data visualization. Holding live virtual demonstrations allowed sponsors to ask questions about tools and see in-depth example use cases.

Another central component of this project was a benchmarking evaluation of generative AI tools to determine their ability to deliver technical content relevant to the natural gas industry. This task focused on assessing whether ChatGPT could accurately respond to domain-specific questions, such as those found on industry certification and qualification exams. These evaluations are essential, as they offer a quantitative measure of AI readiness for operational use. Eight tests, containing a total of 166 questions and ranging from a first responder natural gas safety quizzes to a GTI Energy gas distribution operations exam, were repeatedly asked to ChatGPT and responses were graded for correctness. The results showed that ChatGPT's GPT-4o model achieved an overall accuracy of 65%. Notably, it performed exceptionally well on less technical questions, with a 98% accuracy rate, but its performance dropped to 61% on more technical content. Accuracy improved modestly when additional context was included in the prompt. Critically, for 35% of questions, ChatGPT varied its response from one prompting to the next, sometimes providing the correct answer and sometimes the incorrect answer. A detailed breakdown of the benchmarking methodology and results is provided in a separate report.

This project is complete and a Final Report was issued in June 2025.

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Center for Applied LDC AI Research

Researchers will evaluate and test the latest AI technologies to determine their applicability to utilities operations including development of AI agent prototypes for high-priority LDC use cases. This research will allow utilities to make informed, strategic decisions about tools' benefits, drawbacks, opportunities, and risks.

Project Description

The Center for Applied LDC AI Research aims to provide LDCs with the necessary knowledge for selecting and implementing impactful AI systems. Phase 2 will build on Phase 1 efforts to offer research assessments of the latest technologies through newsletters, demonstrations to test real world AI competencies, and AI agent development prototypes for high-priority LDC use cases.

The rapid evolution of AI from theoretical research to commercially viable products has created a challenge for energy organizations. LDCs must determine which AI systems can be effectively leveraged for their specific needs, and which will offer sufficient return on investment. This requires careful evaluation to understand the advantages, disadvantages, risks, and opportunities for investing in and deploying various tools.

This project will continue the activities initiated in Phase 1, including regular monitoring of the latest technological developments related to AI and assessing the potential for LDC business impact, and demonstrating the capabilities and competencies of select tools on the market. The team will collaborate with sponsors to identify a select number of LDC resource-intensive processes. The team will design and test AI agents to perform the selected processes, and evaluate the benefits, risks, and limitations of their performance.

Deliverables

Deliverables for this project include quarterly newsletters distributed to all sponsors, live demonstrations of emerging AI tools with recordings available after the sessions, and a report sharing key learnings from industry engagement.

Benefits

There will be an increasing number of commercially available AI products, including AI agents, that are either tailor made for energy or utilities applications, or are designed for broad use cases relevant to utility organizations. It's important to evaluate these tools using standardized methodologies so that utilities can make informed, strategic decisions about tools' benefits, drawbacks, opportunities, and risks. This project addresses the possibilities and risks created by emerging technologies by equipping utilities with the insights and tools necessary to evaluate their need for and the usefulness of AI.

Technical Concept & Approach

Since AI is a rapidly evolving field, with new threats (e.g. misinformation, unintended consequences, and privacy concerns) and opportunities arising frequently, the following tasks will be ongoing throughout the project's timeline. This strategy ensures the program continuously monitors this fast-paced area.

The team will continue to investigate and document emerging opportunities in AI, emphasizing content types, models and outputs, and companies in the space as they relate to utilities. Research will focus on the current capabilities and uses of the technology, as well as risks, for various AI use cases, with key information disseminated through a quarterly newsletter to project sponsors. The team will also host live demonstrations for sponsors to show the capabilities and limitations of novel AI tools that have recently come to market, with sponsors invited to provide input on testing tools and recommendations for future demonstration topics.

Additionally, the team will collaborate with sponsors to identify manual processes commonly performed by LDCs that could be automated or improved by using AI agents. The team will design and test AI agents to perform LDC-relevant tasks, and evaluate the benefits, risks, and limitations of their performance. Challenges and recommendations will be summarized to enable LDCs to weigh the costs and benefits of leveraging AI agents for everyday business operations.

Results/Status

The team resumed a quarterly newsletter to share recent AI advances and pertinent headlines. Research for the first newsletter commenced immediately after the project kick-off call. Key outlets monitored include Bloomberg, WIRED, Axios, The New York Times, The Guardian, and arXiv.

At the project kick-off call, the team shared a preliminary list of demonstration topics, with the first focused on showcasing a diverse selection of free AI tools that can enhance productivity across a wide range of roles. To identify which tools to highlight, the team compiled and categorized a table of known free AI tools into the following groups: Research & Knowledge Management; Graphics, Design, & Visualization; Automation & Workflow Management; Meetings & Scheduling; Project & Task Management; Communication; Writing & Content Creation. The first live demonstration was held in November featuring free AI tools designed to support everyday work activities across various roles.

The project team identified five platforms for potential use in developing AI agents. These platforms were selected based on their compatibility with systems already in use by sponsor organizations, as well as their reputation for driving innovation in the AI space: OpenAI Agents, Amazon Bedrock, Azure AI Foundry, Claude Agent SDK, and Copilot Studio. The market for AI agent platforms is rapidly evolving, with new capabilities emerging regularly. However, comparative research across platforms remains limited. To avoid drawing broad conclusions based on a single solution, the project team anticipates testing multiple platforms.

For more information:

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Commercialization of GSA Smart Pole

The objective of this project is to evaluate the integration of the GNSS Smart Automation (GSA) technology into a working commercial GNSS receiver, to assess the effectiveness and viability of the receiver, with the eventual goal of entering into a long-term license agreement with a technology provider.

Project Description

Improving the accuracy of location data has become increasingly crucial to the gas industry. OTD has invested in several project phases to develop the GNSS Smart Automations (GSA or “smart pole”), which resulted in a patent that was issued in August of 2021. This patented technology aides in increasing the quality of their data through an automated data collection process. This project will work with the prospective commercializer to integrate the GSA technology into their GNSS receiver, field test it, and finalize terms for a commercial license.

Deliverables

The deliverables for this project include field demonstrations and tests of the technology in a working GNSS receiver prototype, an active commercial license agreement to market this technology, and a final report.

Benefits

This technology automates the process of collecting high-accuracy GNSS data by field crews, improving data through greater precision, consistency, and reliability. This also reduces the time and personnel required for data collection, lowering costs and improving overall efficiency.



GSA Devices shown with Phase 2 Enclosure and Features

Technical Concept & Approach

Specific tasks in this project include:

Knowledge Transfer

As the initial step in this task, the team in collaboration with Technology partner will transfer knowledge related to the IP to integrate the software into the commercializer's GNSS receiver. The team will then implement and test the GSA technology in a working prototype.

Pilot Demonstration and Sponsor Feedback

During this task, the project team will work with the technology partner will coordinate requirements gathering sessions with all sponsors in order to understand the expectations of the equipment and understand their current needs. From there, 1-2 chosen sponsors will conduct pilot demonstrations to test deployment and usability in the field. The results will inform the commercialization planning. Pilots assume that 1-5 devices will be deployed in the field for short duration pilots (2 weeks to 2 months).

Commercial Plan Development

The project team will work with the technology partner to finalize the terms for a commercial license agreement, with the intent to successfully market this technology both within and outside the natural gas industry. The pilot demonstration will provide information for the commercialization task.

Results

This project is the culmination of work begun in 2017, inspired by the realization that workers trying to measure the geographic positions of physical assets using Global Navigation Satellite System (GNSS) receivers can - unknowingly make errors that can result in inaccurate measurements. . GTI Energy developed the GNSS Smart Automations (GSA) technology to address this issue by breaking the data-collection process into simpler, sequential sub-processes, rather than the conventional

method that requires data-collection personnel to perform multiple actions simultaneously. The separation of these steps not only ensures accuracy but also enhances safety by reducing the time spent in potentially hazardous environments.

The GSA technology was refined over successive OTD project phases. GTI Energy applied for a patent on this concept in December 2018, with a US patent being awarded in November 2021. The GSA technology was refined over successive OTD projects. This phase involves implementing it in a commercially available GNSS receiver.

The selected commercialization partner implemented the GSA technology in their receiver and mobile app to create a new feature. Testing of the new feature was conducted on the GTI Energy campus, indicating a successful implementation.

In collaboration with technology partners, GTI energy conducted demonstrations for project sponsors to get feedback on the new feature. In formal feedback via survey, participants gave the technology high ratings for ease of use, user friendly design, and improvements in safety and efficiency in the surveying process.

The GSA was developed to enhance the accuracy of position data collected in the field. Results showed that this technology may also aide in lower safety risks for field operators by decreasing the time spent in hazardous environments, such as roadways or perched over trenches, and it gives them as much time as they need to record their data in a safer location.

This project is complete and a Final Report was issued in December 2025.

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Dynamic Grid Management

Researchers will assess the feasibility, time, and funding required to extend existing gas flow modeling software, or develop new approaches, that would help operators dynamically manage biomethane and hydrogen injection rates into their networks. Such a capability would let operators optimize the quantity and timing of these injections while guaranteeing continuity of supply.

Project Description

This project will explore existing software flow modeling packages, or new approaches to determine the feasibility of using their output calculations to help operators dynamically manage the flow rates into their system from biomethane and hydrogen injection locations. Commercially available dynamic flow simulation and modeling software systems were built to take into account a rather homogeneous gas (e.g., natural gas) and predict system pressure conditions under varying gas demand scenarios (usually dependent on weather, customer operations, unplanned events, or other “What if” scenarios). Today’s operators are facing new challenges by bringing biomethane/renewable natural gas (RNG) and hydrogen into the mix.

Current software modeling tools are being enhanced to allow for users to vary the factors necessary to better characterize the equation of state caused by gas composition changes, and hence improve modeling performance accuracy. However, operators need a way to predict and model how different injection scenarios from these new variable flow rate sources of supply will affect the balance of their system inputs, as well as gas composition delivery at end points from both a technical and commercial/contractual standpoint.

At present, no known commercially available flow simulation and modeling software packages allow for changes in flow availability and/or limitations from various sources of supply (such as from biomethane and hydrogen injection points) into the natural gas network flow modeling. This project will begin dialogue and outreach with software providers and explore the feasibility of incorporating these features into one or more vendor products, or the need for future development of such a tool. This project will not undertake the effort to add these features but will instead focus on the feasibility, time, and funding required to do it or develop it.

Deliverables

Deliverables for this project will include an outline of a series of future tasks and of existing and future datasets that can be used for validation of each modeling approach. When a potential viable pathway is identified, the deliverables will also include a time and budget estimate. A final report will also be provided.

Benefits

The modification to an existing flow control model, or the development of a new one, with the ability to balance flows in and out of the system based on varying sources of supply would be of great value to optimize and inform the remote control of the various system sources of supply.

The goal of adding these features is to optimize quality and cost of delivery, under various flow demand conditions such as winter and summer; ensure gas quantities and quality from biomethane plants are considered; allow the favoring of one source of supply and type of gas mix strategy vs another; and allow operators to evaluate and predict the effects of different injection scenarios on flows from other supply locations and the resulting pressure losses throughout a networked system. Additionally, a well balanced dynamic network operation can lead to the optimal network operating scheme (positions of valves, regulating/transmission stations, injection pressure) according to the following priorities: guaranteeing continuity of supply; optimizing or maximizing the quantity and timing of biomethane or hydrogen injected into the network; respecting the injection order as contractually defined; and limiting the number of operating set ups.

Technical Concept & Approach

The team will define the set of optimization challenges that need to be addressed from the various pipeline system operators, which will direct the

efforts in the remaining tasks. This will start with a review of existing methods and software tools available to utilize and/or build off of.

Once vendors of potential software models/tools are identified, the work will then include planning and conducting meetings with vendors. SMEs at individual vendor companies will be identified and detailed technical discussions will take place. An outline of a series of future tasks to tackle the issues as well as identify existing and future datasets that can be used for validation of each modeling approach will be developed and reported on. When a potential viable pathway is identified, a time and budget estimate will be developed with the vendor/developer and reported on.

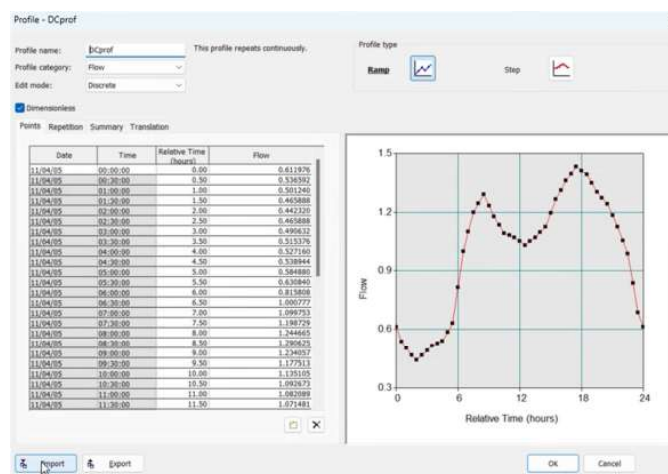
Additionally, typical cases where flow control solutions are needed to optimize the operation of a network will be further investigated with operators to build up the list of data sets needed in the future to validate the model/tool. Operator input will be used to identify possible monitoring solutions that would have to be implemented to operate the network using remote equipment informed by the use of such a model.

Results/Status

The project team held meetings with project sponsors and the champion sponsor to define the needs of the dynamic grid software. The software needs were defined as a system that allows for both modelling system behavior and monitoring system measurements (pressure, volume, and flow rates) at multiple locations throughout the system.

Research meetings were conducted to explore various hydraulic modeling software packages available in the industry. This project evaluated four software packages. One product's suitability for modelling natural gas distribution systems was unclear, but the remaining three products were all capable of performing steady state analysis of natural gas systems with biomethane/RNG and hydrogen injections. Those products could also perform different methods of analysis to simulate a true dynamic analysis. This included multiple steady state analyses to evaluate different scenarios and transient analysis to evaluate time based system response. Two packages also had the ability to connect to a utility Supervisory Control and Data Acquisition (SCADA) or other data system to automatically transfer data into the software for analysis.

Of the packages explored, one package stood out



Input screen for Synergi Gas time-varying module. (Source: DNV)

as having all the features requested by sponsors. A trial license for that package was granted and the package was explored by the team. Discussions with an external subject matter expert helped the project team confirm the software features would meet the requirements of project sponsors. A presentation was created to go through the features available in the software. The presentation was reviewed with the external subject matter expert, and was presented to the champion sponsor in early Q1 2026.

Operators that have sponsored this project have indicated that their steady state hydraulic models are manually updated on a periodic basis and that they did not have the capabilities for real-time data to populate their hydraulic models. There is a lag time from the point of actual field reading to the point of data entry into the model to truly define whether a model is dynamic. Further research is needed to evaluate the efficacy of the software packages at operating a system dynamically including the ability of field sensors to provide data to populate a model in real-time. Additionally, the software packages could also be further developed to integrate directly into a control system to optimize system analysis, operation, and response. The project team will discuss with sponsors a potential Phase 2 project to work with a software vendor and a champion toward the creation of a dynamic solution for a selected use case.

This project is complete. A Final Report was issued in April 2026.

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Using High Resolution Imagery and ESRI Deep Learning to Identify Roadway Moderate Consequence Areas

Researchers will develop a GIS based workflow using Esri Deep Learning packages and high resolution satellite imagery to automatically identify four-lane paved roadways for pipeline Moderate Consequence Area analysis, replacing a manual digitization process and enabling efficient monitoring of roadway changes.

Project Description

This project will demonstrate the ability of Esri Deep Learning packages to identify four-lane paved roadways. The data can then become a polygon dataset for calculating pipeline Moderate Consequence Areas (MCAs) and digitizing a manual process.

Part 1 of the PHMSA Mega Rule extended pipeline assessments into MCAs, requiring transmission operators to identify all MCAs along their pipeline system by July 2021. One type of MCA is based on human occupied structure data an operator collects, while the other is based on where a pipeline potential impact radius (PIR) intersects a four-lane, paved, primary arterial roadway. Operators must develop roadway polygon datasets for MCA analysis, and are tasked with keeping up with applicable roadway expansions and reroutes.

A systematic approach to monitoring a pipeline footprint using high resolution imagery and Esri Deep Learning packages may provide transmission operators with an efficient way to maintain their MCA roadway datasets.

Deliverables

Deliverables for this project include a repeatable GIS based workflow for identification of four-lane paved roadways using Esri Deep Learning packages and high resolution satellite imagery, a roadway polygon dataset derived from Esri Deep Learning imagery analysis results, an intersection analysis demonstrating MCA range generation on a pipeline dataset, and a comparison of project generated results against sponsor volunteered MCA data.

Benefits

The primary benefit will be the time and labor savings from having to identify and digitize Moderate Consequence Area (MCA) roadway boundaries manually. A GIS based workflow will replace the manual process. The workflow will also help operators stay up to date with roadway expansions and reroutes. A set process for identifying and revising roadway MCA boundaries will strengthen Integrity Management Programs.

Technical Concept & Approach

Work will focus on the development of a repeatable GIS based workflow using the Esri Deep Learning packages and high resolution satellite imagery to identify four-lane paved roadways, including shoulders and exit/entrance ramps per PHMSA guidance. The developed project scope will include literature review and best practices research, imagery acquisition and data training review, Esri Deep Learning package training, and GIS based workflow development.

A literature review of GIS based workflows that integrate deep learning and object recognition applications for satellite imagery analysis will be conducted, along with a review of satellite imagery processing methods. High resolution aerial and satellite imagery of four-lane paved roadways will then be acquired to train the Esri Deep Learning packages. Researchers will identify the best techniques and deep learning training methods to use and refine the results.

A GIS based workflow will be developed using the refined practices to produce a viable roadway

polygon dataset derived directly from the results of the Esri Deep Learning imagery analysis. The polygon dataset will also be used to demonstrate an intersection analysis to generate MCA ranges on a pipeline dataset. The project will conclude by comparing results generated in this project to sponsor volunteered MCA data.

Results/Status

The literature review confirmed that the process of extracting roadways from satellite and aerial imagery is well documented and has been in practice for more than 20 years. The process of creating labeled training data revealed several preliminary challenges. One key issue involved areas where tree canopy obscured the roadway, potentially hindering the deep learning model's ability to accurately detect road features. Additional complexities arose in training the model to recognize highway on-ramps and off-ramps, which are included as part of applicable moderate consequence area (MCA) roadways. Further challenges included accurately digitizing transitions where two-lane roads expand into four lanes, either permanently or temporarily at intersections due to turn lanes, before narrowing back to two lanes.

The team manually digitized over 35 non-MCA roadways and around 10 MCA roadways using 0.5-meter resolution satellite imagery. However, a large amount of labeled data is needed to train a deep learning model, and additional approaches were explored to overcome this challenge. The team began to incorporate the labeled data set into existing pre-built deep learning models available from Esri. Additional labeled training data was acquired from project sponsors, and the labeled MCA roadway dataset was incorporated for model training using Esri's deep learning packages and ArcGIS Pro.

The team will continue working with the project sponsor to receive the MCA roadway data set that will be used for model training. The training data set will be prepared and any needed data clean-up performed prior to training the model. Once the model training is completed, the model will be evaluated using a validation data set to compare the results.

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Digital Product Catalogue Startup for the Natural Gas industry

The team will establish a Utility Data Pool, a shared catalog on the Global Data Synchronization Network (GDSN) where pipe and equipment manufacturers publish detailed product data that utilities can pull directly into their own systems. This project will demonstrate how a single mobile system can provide track and traceability information for transmission projects, and the same GS1 standard can be used by utilities for gas transmission and distribution components as well as for electric, water, and telecommunication components.

Project Description

The project will create a product catalog service for the utility sector, providing detailed information on each manufacturer's products, and build a scaled commercial platform that leverages existing pilot project systems. Changing from paper based to digital data collection requires detailed definitions of each component's attribute information for system modeling and regulatory compliance.

Early digital data collection systems attempted to include product attributes in the data carriers (barcode or RFID) printed on or attached to the component. This process is effective for small amounts of product information. However, it fails as the product information required under regulation or business needs change and exceeds the barcode capacity (data carrier). This problem was recognized well over 25 years ago in many highly regulated industries: pharmaceutical, food processing, grocery, automotive, etc. In 2004, the Global Data Synchronization Network (GDSN) was started as a global, internet based initiative that enables trading partners to exchange product master data efficiently.

The project will establish a new Utility Data Pool, managed by the project team, that will contain product data for utility piping and equipment providers. The team will concentrate on launching this service for natural gas steel pipeline products used in both transmission and distribution. Initially, the focus will be on pipes, pipe fittings, and flanges. After the system's initial startup and confidence in the supply of services is gained through this project, the team will extend the service to include natural gas assemblies (valves and other appurtenances).

Deliverables

Deliverables for this project will include a new Utility Data Pool containing product data for pipe and equipment manufacturers, along with the first product load sheet for bulk loading product data into GDSN. A final report will detail the different classes of products included in the product catalog collection, and user documentation will be provided to manufacturers wishing to register their products in the data pool.

Benefits

Machine identification of utility components using F2897 type technology has been successful; however, with each regulatory change, new capabilities must be added to the underlying standard (ASTM F2897). The utilities need the ability to change the machine readable content in the barcode (data carrier) for regulatory compliance using predefined and standardized schema elements called Application Identifiers. The use of modern identification standards would prevent extensive change programs and the associated costs of implementing and disseminating the changes.

This project will demonstrate how a single mobile system can provide track and traceability information. This standardized GS1 system can be used by utilities for gas components (transmission and distribution) as well as for electric, water, and telecommunication components.

Technical Concept & Approach

This project will establish GDSN services that will automatically provide the mechanisms for product content upload, exchange, and maintenance. The team will lease the GDSN service environment from a GDSN service provider, manage the Utility Data Pool for the natural gas industry, and provide the customer interface for all natural gas industry trading partners.

The team will define the overall activities and participants involved in the effort. It will also specify the manufacturing companies that will develop their digital product catalogs. Additionally, it will identify the utilities that will subscribe to the digital catalogs and utilize the information in subsequent business processes (construction documentation, receiving inspections, warehousing, and engineering design).

The project will establish a contract with the GDSN service provider to provide GDSN services, enabling the team to act as an agent soliciting electronic product catalog data from each manufacturer. This service will provide the data in a web-based system that the manufacturer can use to share with utilities, engineering design companies, and inspection service providers.

The team will seek manufacturing organizations interested in understanding the value of their product data when converted and delivered in digital form. The project will load the commonly manufactured product information from the catalogs representing the most frequently ordered products annually. The team will work directly with the manufacturers to understand the process of loading, publishing, and updating product records to support new business and enable construction documentation operations using the mobile data collection application. The project will also provide consulting services to assist and train manufacturers in using the tools in the GDSN web interface and to establish the first product load sheet for bulk loading product data into GDSN by modifying the existing load sheets used and developed on previous pilot projects.

Integrated back office applications have been built to stage the electronic catalog data from several manufacturers to support the two pilot projects completed with a partner utility. The team will update these systems to process the data extracted from GDSN and support the mobile data collection platform, and to make these services available for other users. The infrastructure will also be updated

to manage access for all manufacturers and utility companies involved and to account for any new attribute information found to be critical to future construction documentation.

Results/Status

Talks with a GS1 certified data pool provider are ongoing to establish the data pool to standardize manufacturer and product data across the energy and utilities sector. The team has outlined the respective business and technical responsibilities associated with establishing the data pool.

The team is conducting a market analysis that encompasses utilities, pipe manufacturers, mid-stream and upstream companies, and others. This analysis evaluates key factors, including estimated pipe length, service regions, customer counts, annual revenue, and other relevant attributes. Project sponsors were engaged to discuss potential assets and use cases for GS1 adoption. The team will also engage sponsors and other industry stakeholders to work together to identify manufacturers that may want to become early adopters of the data pool.

Progress on updating API RP 5MT to include two annexes for machine readable identification marking systems for line pipe was also monitored. The modifications were approved, and work with the API group toward publication is ongoing.

The team conducted a literature review and landscape analysis for intelligent document processing (IDP), robotic process automation (RPA), and emerging generative AI methods for digitizing paper based documents. Market research indicates that these three fields are increasingly intersecting, with traditional IDP companies integrating generative AI models and methods, with many now also offering RPA services. For this research cycle, the team engaged with multiple companies and IDP service providers to assess quality of output, using hand filled leak survey forms as a sample. Output from a proof of concept with one provider will be shared in the first quarter of 2026. In tandem, the team is exploring the viability of using open source generative AI methods for the same task, with experimental design ongoing and development scheduled for early 2026.

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LiDAR Data Creation and Classification to Enable Utilities Applications

Researchers will collect LiDAR data and develop object detection and classification models that expand the range of assets and events LiDAR platforms can recognize, enabling utility applications such as encroachment detection in the right-of-way. This work will give utilities a low cost, higher resolution means of monitoring sensitive assets that improves worker and asset safety and supports regulatory compliance.

Project Description

This research aims to bridge the data gap between utility needs and the current state of LiDAR platforms and to enable new object classifications and use cases. The project seeks to collect LiDAR data and create classification models focused on object detection to enable utility applications like encroachment detection in the right-of-way. The team will seek to explore commercialization of data collected to grow utility applications across LiDAR platforms and has partnered with a LiDAR sensor manufacturer and platform provider, the vendor selected following a market review in OTD project 8.23.k, to ensure strategic, targeted project work to push forward industry use cases.

A LiDAR industry survey for 8.23.k Ground Cover Change Detection shows potential for LiDAR applications in the utility space, especially as a monitoring application to promote better worker safety and asset protection, facilitate encroachment monitoring, and comply with regulatory requirements. However, it also revealed the limits of event detection platforms at present such as limiting the identification of five to six object classes, in tandem with a handful of parameters like user-defined zones, velocity, and idling duration.

The scope spans asset identification and requirements gathering, LiDAR field data collection, review and labeling of 3D point cloud data, semantic segmentation model training, and commercialization to support LiDAR platform adoption of utility focused point cloud data.

Deliverables

Deliverables for this project include a literature review and requirements report, a LiDAR field dataset, point cloud data augmentation test results, a labeled 3D point cloud dataset, and a trained semantic segmentation model with evaluation and post-processing outputs. The project also delivers a commercialization strategy and partnership agreements, a workflow review, and technical reporting documents.

Benefits

The benefits of improving LiDAR platforms, especially for event detection, are numerous: improved safety outcomes for workers and assets; lower cost, improved monitoring workflow; easier, documentable regulatory compliance; and 24/7 monitoring using more precise technology.

Technical Concept & Approach

The work will focus on collecting LiDAR point cloud data to enable the identification of assets and event detection. The team will collect data, review methods for labeling point cloud data, conduct modeling, and explore commercialization opportunities to spread utility focused point cloud data to platform operators.

The scope will include identification of assets for classification and relevant scenarios that should trigger event detection, and requirements gathering, to determine the quantity of data needed and relevant parameters for LiDAR data collection. The

team will then use this information to develop and implement a plan to collect the required field data and create the LiDAR dataset focused on field assets.

The team will also review and test current software and open source models for labeling 3D point cloud data, and use this information to label the point cloud representation of assets. The team will then perform semantic segmentation model training, evaluation and post-processing activities.

Additionally, the team will explore commercialization opportunities to support LiDAR platform adoption of utility focused point cloud data to enable targeted object classifications and support widespread adoption of utilities use cases.

Results/Status

Round 1 of data collection was completed, and an end-to-end workflow was developed to ingest data from the hardware vendor's platform into the labeling platform. This included defining data transfer steps, validating formats, and outlining a clear path forward for systematic data labeling in subsequent phases. Integrating the two platforms required overcoming several technical hurdles, including intermediary processing steps and iterative troubleshooting to resolve compatibility and workflow issues. Addressing these challenges resulted in clarified requirements for future data collection and labeling.

Team members explored data using the vendor's web platform. Two members drove several miles over the course of a few hours, gathering data in the suburbs surrounding the team's office. The collected data covers a range of road and construction conditions and will be used for further analysis and evaluation, and the team collaborated with partners at the hardware vendor to properly upload the data for labeling.

The team reviewed current research on using synthetic point clouds to enhance LiDAR computer vision models, particularly for underrepresented object classes like steel plates. While promising methods are emerging, they remain unsuitable for this project phase; the team will continue to track advances that could become applicable as the project progresses.

For 3D point cloud labeling, meetings were held with the labeling platform and the hardware vendor to gain insights into their respective platforms. The complete dataset acquired through the hardware vendor will be downloaded and processed in batches to identify which road segments should be selected for cone labeling activities in the upcoming quarter.

During the initial phases of model planning and dataset exploration, the team reviewed the data needs for different 3D point cloud processing approaches. Because 3D data alone can be difficult to collect at the needed scale, the team is exploring ways to combine LiDAR data with 2D image data to improve object recognition while reducing data collection burden. This direction supports a more scalable approach that uses both LiDAR and camera data.

The team also reviewed public information on planned construction activity in the selected collection area. A team member visited locations where the interactive map showed active dig tickets, and construction activity was observed at one of five investigated locations. This review showed that dig tickets are useful for identifying potential areas of activity, but the timing of field work may not align exactly with the listed dig date or expiration date. The team is exploring additional data sources to supplement the dig ticket database and interactive map and help better identify locations with active construction.

The team will conduct independent analysis of data collected using the vendor's equipment, including exploring a workflow involving the labeling platform for LiDAR data labeling and modeling. In the Spring, the team will collect a second round of data to supplement the existing dataset, and will document a workflow and commercial options for using LiDAR and other visual data sources to monitor road conditions above subsurface assets.

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AI Solutions to Digitize Paper-based Data and Manual Entry Workflows

Researchers will evaluate intelligent document processing, generative AI, and robotic process automation methods to digitize historical paper records and streamline manual data capture, using leak detection surveys as the initial use case. This work will improve record accuracy, repeatability, and regulatory compliance while reducing the errors, corrections, and costs associated with paper-based processes.

Project Description

This research will evaluate methods for digitizing historical paper forms and approaches for incorporating AI into manual data capture and entry processes to streamline efforts and reduce user input variability, which can lead to errors, corrections, and associated risks. Work will focus on leak detection surveys as an initial use case, with the goal of identifying solutions and workflows as a deliverable. Researchers will review and leverage intelligent document processing (IDP), generative AI, and robotic process automation (RPA) methods to improve data capture and historical data digitization.

Deliverables

Deliverables for this project include reviews of digital tools to correct errors collected during current paper based processes, an overview of methods to review and improve data capture, and market survey and literature review results for IDP, RPA, and generative AI. The project also delivers workflows for improved data processing and digitization, a performance evaluation of the developed workflow(s) and model(s), and a final report documenting results, assessments, and performance evaluations.

Benefits

This work will improve record quality, regulatory compliance, productivity, and outcomes. The research will focus on identifying more efficient data capture processes, leading to improved record accuracy, repeatability, and reproducibility. Record uniformity will enable more efficient and lower-cost reviews and approvals and reduce risks from non-conformances, including fines stemming from poor record quality.

The industry will benefit from digitized historical records by enabling modeling, analysis, and insights

to inform work practice. Workflow assessment and review will streamline data capture workflows, improving organizational efficiency, productivity, and data quality, and lowering maintenance costs.

Technical Concept & Approach

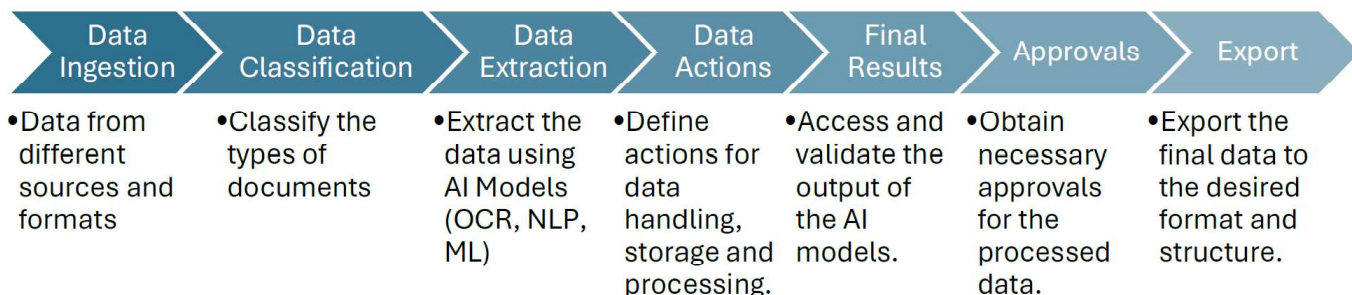
The scope will include review of standardized leak detection surveys and current data recording processes for conversion, either stepwise or in full, into a digitally enabled process that leverages intelligent document processing (IDP), robotic processing automation (RPA), and generative AI tools. The team will convert paper based forms into a database structure, and consider ideal modeling capabilities following conversion of paper based data to a digital format, so that they can be accounted for in data capture and storage.

The team will complete a market survey and a literature review on IDP methods for digitization of paper based forms. The team will also complete a market survey and a review of RPA tools for reviewing and simplification of organizational processes. Additionally, the team will review and test emerging generative AI methods for the digitization of paper based forms.

The team will procure any relevant software licenses identified during the market survey and literature review tasks as it seeks to develop and test workflows that leverage methods identified for improved data processing and digitization, either in part or in full. The team will then review, evaluate and document the performance of the workflow(s) and model(s) created during workflow development and testing.

Results/Status

The team reviewed standardized leak detection surveys and current data recording processes at the site for applicable Intelligent Document Processing (IDP) and digitization methods. A sponsor



call was held to discuss current practices for leak detection surveys and data recording, including the mix of digital vs. paper based methods. The team drafted a database design that included key-value pairs and datatypes, and considered how IDP software should subsequently store that data following conversion. In addition, the team drafted a workflow for converting hand-drawn geographic data to geodata for display in GIS software. The leak surveys utilize a variety of input modalities, including textual information, signatures, checkboxes, tables, and grid based hand-drawn data; following extraction by IDP software, large language models (LLMs) or comparable technologies, it will be possible to convert paper based data and geo-reference it, at scale.

The team completed a market survey and literature review of IDP methods for the digitization of paper based documents and a market survey and literature review of robotic process automation (RPA) tools for reviewing and simplification of organizational processes. The team identified three software options each for IDP and RPA and completed licensing where needed. A proof of concept (PoC) with an IDP solutions provider is underway as part of the form capture workflow task. Preliminary findings indicate that the IDP software market is both competitive and mature, offering scalable solutions for data capture, document classification, and workflow automation. Preliminary research also identified several RPA software vendors offering scalable automation platforms with AI and machine learning integration. Many IDP models are pre-trained, thus requiring less training data (around 25 populated examples) for pilots and proofs-of-concept relative to other machine learning tasks.

For the generative AI task, the team investigated offline and online AI engines across the LLM and Vision Language Model (VLM) technology landscape. The team assessed open source models hosted on public model repositories, examined specialized OCR engines and multi-modal models suited for document digitization, and reviewed commercial cloud API services to understand their

performance, scalability, and integration potential. Following a preliminary review of current methodologies and market trends, it appears that VLMs will likely integrate closely with IDP processing, as this approach accommodates both text and image input modalities.

For the form capture workflow task, the team constructed an Intelligent Document Processing (IDP) workflow that automates the extraction of structured information from physical or digital forms. Advanced OCR and Vision Language Models extract key information, including fields, tables, checkboxes, and handwriting, with high accuracy, while machine learning maps the data to templates or adapts to new layouts. The team set up cloud resources and a working group to support testing and compared several content extraction approaches. Workflows were executed locally using offline AI engines, and research on extending capabilities through cloud API based AI and OCR services is now underway. The PoC is in progress and approaching its final stages, with preliminary data indicating consistently strong performance in converting handwritten text to digital format.

Market research indicates that IDP, RPA, and emerging generative AI methods for digitizing paper based documents are increasingly intersecting, with established IDP companies integrating generative AI techniques into their document processing workflows and many now also offering RPA services. Ongoing subject matter expert review remains critical to ensure that industry-specific fields are accurately and appropriately processed. For this research cycle, the team engaged with multiple companies and IDP service providers to assess quality of output, using hand-filled leak survey forms as a sample. In tandem, the team is exploring the viability of using open source generative AI methods for the same task.

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Understanding the Relationship Between Changes in Gas Demand and Pipeline Safety Risks

This project will enhance a gas distribution network model to evaluate how declining gas demand affects gas distribution network leakage rates, cost, and risks, providing utilities with data driven insights and practical recommendations. The results will help utilities maintain high safety standards and inform rate cases should gas demand decline.

Project Description

Building on the Natural Gas Trends (NGT) model developed as part of the Natural Gas Bans project (9.24.a), the team will produce a scientific analysis and assessment of the key factors that impact maintenance costs and managing risks in different networks undergoing gas demand changes, and enhance the model to assess the implications of maintaining high safety standards under alternate scenarios of gas demand change due to state-level decarbonization policies.

Natural Gas Bans and Future of Gas Proceedings in a number of US states have suggested that gas utilities would have fewer customers, lower network utilization, and higher operating expenses per customer. Energy systems models such as the LCRI Net-Zero 2050 have assumed that gas pipeline infrastructure could be maintained at capacities comparable to today even in scenarios with less than 20% of total gas demand, necessitating a more in-depth analysis.

Deliverables

Deliverables for this project include a literature review summary chapter, a data sources summary, a detailed explanation of NGT code improvements, the NGT Power BI web-based reporting tool with scenario simulation results, a final report with executive summary, and a final presentation.

Benefits

Researchers will provide a scientific analysis and assessment exploring the interaction between gas distribution network leakage rates, costs, risks, and gas demand. This will enable utilities to develop plans and rate cases for regulators to ensure they can afford to maintain high safety standards should demand decline due to state-level decarbonization policies.

With a number of US states enacting Natural Gas Bans and undertaking Future of Gas Proceedings, there is an industry need to understand how utilities can remain economically viable and maintain high safety standards while undergoing changes in demand for distributed gas.

Technical Concept & Approach

A review of literature around modeling gas pipeline leakage and safety risks will ensure modeling reflects best practices in capturing relationships between pipeline and geographic characteristics, leakage likelihood, and maintenance costs. Data collection and preparation will gather relevant data sources including infrastructure maps, geographic and geologic information, safety regulations, and cost data, and analyze data to identify trends, patterns, and dependencies to inform model structure and parameters.

Model development and testing will alter and test code changes to the NGT system to incorporate gas leakage, risk, and maintenance algorithms and metrics into the existing NGT decision-making under uncertainty framework. Scenario simulation will run a series of systematic model runs examining the impact of geographic and network factors and their relationship with scenarios of future gas demand. Simulation results will be incorporated into the NGT Power BI web-based reporting tool for sponsor investigation. Findings will be documented in a final report and presented at a US national conference.

Results/Status

The scope of work was divided into two phases: Phase 1 focuses on the relationship between gas demand and risk, and Phase 2 incorporates cost.

A functional specification document was produced outlining the analysis being undertaken and the functionality that needs to be built for both phases. An extensive literature review on how risks and costs have been understood and modeled in the past by academics and industry was conducted and recorded for inclusion in the final report. The literature review revealed that although researchers have been able to simulate different leak detection and repair (LDAR) programs for gas wells, including their costs, only risk has been modeled and analyzed for gas distribution networks. The primary reason, according to discussions with published authors, is that data for LDAR programs for gas

distribution are not publicly available. This gap in available data resulted in rescoping the project to focus on only evaluating risk.

Sufficient data to undertake Phase 1 was secured, including population densities at a granular level from the 2020 Census dataset. The GTI BRD (birth, detection and repair) model was incorporated into the NGT Safety module with a focus on providing Phase 1 functionality, and the safety module has been run successfully within the NGT framework using training data. Model development and testing is approximately 40% complete. Draft versions of the Introduction and Literature Review for the final report have been completed.

Scenario simulations were expected to begin ahead of schedule in March 2026. After finishing Phase 1, the team plans to present results to stakeholders and discuss whether to proceed with Phase 2.

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Industrial Control Systems Operational Cyber Threats Assessment and Alerts

Researchers will develop an automated monitoring system that reviews Cybersecurity and Infrastructure Security Agency (CISA) alerts and compares them against a database of Industrial Control Systems (ICS) hardware used in the natural gas utility sector. This work will give sponsors timely, targeted notifications of vulnerabilities affecting their equipment, enhancing the security and resilience of critical infrastructure against cyber threats.

Project Description

This project will enhance infrastructure safety by leveraging data from CISA to identify vulnerabilities in ICS and provide targeted alerts to sponsors. An automated system will review CISA's alerts and compare them against a database of ICS hardware.

ICS security presents unique challenges. Traditional ICS devices, essential for managing industrial processes, can be difficult to secure without causing unacceptable disruptions. As ICS manage physical operational processes, the increasing convergence of information technology (IT) and operational technology (OT) creates exploitation opportunities that could lead to catastrophic consequences, including economic damage, disruption of critical infrastructure, and even loss of life, .

Cyberattacks on industrial infrastructure pose significant risks, particularly when targeting control systems. These systems are crucial for the safe and efficient operation of natural gas infrastructure, and any compromise can lead to severe disruptions, safety hazards, and financial losses.

Deliverables

The deliverables for this project is an automated monitoring system that reviews CISA's ICS vulnerabilities alerts and notifies sponsors of relevant threats based on a sponsor-supplied database of ICS components via email

Benefits

Cyberattacks on critical infrastructure increased by 30% in 2023, resulting in an average cost of \$9.36 million per incident. By providing timely, ICS-specific vulnerability alerts drawn from CISA's advisory list, this project will support sponsors' safe and efficient operation of control systems while protecting against these threats.

Technical Concept & Approach

The team will collaborate with sponsors to identify the specific ICS used in their facilities and to understand their preferred methods for receiving vulnerability alerts. Sponsors will also be able to update the ICS components database to keep the information current.

The team will review CISA's ICS alerts to identify potential vulnerabilities, and develop an automated monitoring system that compares these alerts against a database of ICS components in the natural gas utility sector. The system will deliver timely notifications to each sponsor using their preferred method, targeted based on their equipment list.

Results/Status

The project team initiated the Cyber Threat Assessment application by establishing a high level architecture and workflow. The team built a data pipeline to download and store all CSAF security advisories.

Industry engagement efforts have centered around designing a survey for sponsors to link CSAF advisories to utility equipment, with categories focused on equipment inventory, threat matching, and notification preferences. The team identified three distinct types of survey categories for the industry engagement survey: Utilities Equipment Inventory Data Collection, which gathers detailed information about utility company equipment to ensure security measures are aligned with CSAF advisories; Threat Matching, which examines criteria and factors used to match equipment inventory against CSAF security advisories to generate accurate, timely, and reliable notifications; and Notification, which gathers insights into utility company preferences for receiving notifications (email, SMS, RSS feeds) and preferred notification frequency.

The most recent milestone completed was the development of a high-level plan for the application and the automation of the process for downloading new CSAF security advisories data. The team is now focused on finalizing the survey that will be sent out to the sponsors. Once the team receives feedback from sponsors, the team will focus on designing the application's database, setting up services in Azure, and developing the application.

The team built an equipment database of the various ICS available on GTI Energy's Des Plaines campus as a proof of concept. A workflow was developed to fetch the security alert information published by CISA whenever a match is found between the ICS equipment database and the CISA security alerts database. This information would be automatically notified to the relevant personnel via email, which is under development. In addition, GTI Energy reached out to the project sponsors for the different ICS that they would like to be monitored for potential cyber threats to continue building out the ICS equipment database.

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Evaluate AI Tools for Tracking Environmental Compliance

Researchers will survey and benchmark AI tools to help operators align with regulations and to determine whether specialized AI solutions offer advantages over general tools. This research will provide utilities strategic insights to inform investment in tools that provide efficiencies in tracking rule changes and ensuring timely filings.

Project Description

Researchers will investigate how AI can support streamlining of regulatory processes for utilities professionals, assess specialized and general tools for compliance support, and determine whether specialized AI solutions offer advantages over general tools. This research aims to provide strategic insights and inform decision making around investments into Large Language Models (LLMs) and other comparable tools for legal rule tracking and compliance purposes for utilities.

Utility companies face complex federal, state, and local regulations. The process of understanding changes in regulation and ensuring that filings are made on time and internal processes updated can be both time consuming and costly, involving significant manual labor to stay up to date with shifting rules. Emerging AI tools show promise, particularly in supporting compliance tasks and the filing process.

Researchers will conduct a market landscape review of general purpose LLMs, specialized and purpose built LLMs and AI based tools for regulatory compliance and change tracking, and other tools built for regulatory compliance. The team will establish a methodology for analysis and tools will then be benchmarked and evaluated according to that rubric.

Deliverables

Deliverables for this project include methodology and benchmarks to evaluate the performance of the tools to be identified, and a market survey report of LLMs, generative AI tools, and other data and tools identified, with recommendations for tools and software to evaluate. Also included are the evaluation of specialized and all purpose tools, a final project report with recommendations for deployment, and documentation summarizing findings on AI uses for rule tracking and compliance purposes.

Benefits

Regulatory compliance and change tracking are time consuming and costly endeavors. Sifting through shifting regulatory landscapes often involves significant manual labor. Emerging AI tools offer the potential to save significant time and money in terms of tracking rule changes and in ensuring timely filings.

In an era of rapidly evolving regulations, it is essential for utilities to be familiar with tools that can help them strategically manage and navigate rule changes and ensure compliance. Exploring tools that build efficiencies when monitoring compliance activities is beneficial. Evaluating both specialized and general AI tools for these purposes will provide timely insights for utilities.

Technical Concept & Approach

The team will interface with sponsors to determine key performance indicators and evaluation requirements for AI tools. The work will involve the creation of comprehensive methodology and benchmarks to evaluate the performance of the tools to be identified. The team will also interface with subject matter experts and conduct research on performance requirements as needed to ensure methodological rigor.

Additionally, the market survey will involve a comprehensive review of Large Language Models, generative AI, and other tools designed for rule tracking and compliance. It will identify commercially available technologies applicable to the utilities sector and evaluate their effectiveness in streamlining regulatory compliance processes. By examining a wide range of tools, both general purpose and specialized, the survey aims to provide a detailed understanding of the landscape, highlighting the strengths and limitations of each solution.

The work will also involve the deployment and testing of the specialized and all purpose tools identified and procured as part of the market survey. Software procurement of the solutions of best fit identified during the survey will take place. The goal, following installation, will be to compare and evaluate the effectiveness of these tools in streamlining regulatory compliance processes, according to the framework established. By thoroughly assessing each tool, the project aims to determine their strengths, limitations, and overall suitability for practical applications in the utility sector.

Results/Status

The team began research establishing regulatory and compliance touchpoints distributed across utility organizations, and relevant roles subject to and responsible for compliance. That work is ongoing and will involve an outreach effort to project sponsors. Benchmarks and tools will ultimately reflect different roles and responsibilities, making this foundational work essential. The team engaged vendors and conducted a market survey to establish a basic understanding of emerging compliance tools in the AI space.

The team completed an experimental design framework to test LLM agent orchestration for evaluating document review for compliance with various regulatory requirements. Each “agent” (an LLM assigned a perspective and specific documents or rules as its frame of reference) reviews a given document for alignment with rules and regulations; the output will highlight and/or format text for an expert’s review, and cite potential conflicts with specific, explicitly named rules. The exact experiment design will be informed by the results of the sponsor engagement efforts.

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Data Systems as Capital

Researchers will characterize the costs, benefits, pathways, and barriers associated with how data and data systems are accounted for by LDCs. This work will help clarify regulatory and accounting considerations while supporting more data-driven, nimble, and efficient utility operations that can improve safety, reliability, service quality, and long-term customer value.

Project Description

This project will develop a white paper that evaluates how costs associated with data and data systems are treated in utility accounting and regulatory frameworks. The findings will characterize stakeholder considerations for data-related investments, including how these investments may support safety, reliability, operational efficiency, and customer value.

Across LDCs, spending on data and data systems often comes from O&M budgets. The process of changing accounting practices draws upon multiple domains of expertise and impacts diverse interest groups. In addition, state and local regulations may affect capitalization.

This project seeks to gather information about diverse aspects of LDC operation and to aggregate the major considerations associated with recategorizing data and data systems as capital. The team, working with project supporters, experts, and stakeholders, will study and document these considerations, with the goal of reducing the “unknown unknowns” in this space. The team will synthesize this information into a report describing the landscape, including pathways and barriers, for treating data as capital, though it will not serve as legal or technical guidance.

Deliverables

Deliverables for this project include a final report that brings together document citations and summaries, stakeholder engagement summaries, and a conceptual roadmap.

Benefits

Modern business practices increasingly rely on data and data systems for operations and decision making, yet existing accounting practices do not always recognize the long-term value these investments can provide to local distribution companies (LDCs) and their customers. Treating qualifying data and data systems as capital could strengthen LDCs’ ability to operate as data-driven enterprises that are more nimble, efficient, and effective. It could also support clearer cost recovery for investments that improve service, safety, reliability, and long-term customer value.

Being more data-driven means that LDCs can also improve safety. Data and data systems can improve decision making, enhance efficiency, gain deeper insights into customer behavior, and reduce methane emissions. Being a data-driven organization also opens new pathways for performance management and innovation. Since data and data systems are currently categorized as O&M, spending on them is constrained when O&M funds are limited.

Technical Concept & Approach

Over the course of 18 months, the team will combine background research with stakeholder engagement to investigate how data has been treated as capital in other industries and the benefits and obstacles LDCs would face in pursuing it.

The background research will involve identifying, reading, and summarizing existing scientific publications, regulations, rate cases, and other documents related to capital and O&M expenses, covering the economic, accounting, regulatory, and scientific facets of the question. This effort will identify barriers and opportunities and assess the

parallels and differences between other industries and the utility sector.

During the research phase, the team will identify stakeholder groups that can provide needed information and, in conjunction with sponsors, develop relevant discussion questions for them. The interviews will be conducted over the course of several months.

The team will then document the results of the background research and stakeholder engagement and synthesize them to identify patterns, barriers, and opportunities.

Results/Status

The team engaged project sponsors and subject matter experts, including accountants, controllers, and auditors, and completed a utility accounting and ratemaking short course to build a stronger understanding of how data and data systems are evaluated in utility accounting. The work showed that treatment of data-related costs varies across utilities and circumstances, with many examples falling into a gray area rather than a single consistent category. The review also found examples where data systems were treated as long-lived investments because they supported customer-facing or operational benefits over time.

Background research and the short course helped clarify common factors that may impact accounting treatment, including expected useful life, connection to new tools or systems, software cost thresholds, and differences between routine data activities and investments that create durable operational capability. The team identified a range of utility examples to better understand how similar investments have been evaluated. Experts also noted that cloud-based systems add complexity because treatment can differ from traditional on-premises systems.

Across ten meetings with seven sponsors, stakeholders emphasized that consistent treatment is challenging because accounting practices, company circumstances, and system design can differ significantly. The team is synthesizing these findings into stakeholder summaries and a draft engagement report that describe the range of considerations, examples, and open questions identified through the project.

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Characterizing the Enduring Role of Gas Across Leading U.S Economy Wide Decarbonization Studies

Researchers will perform a recurring meta-analysis of leading U.S. economy wide decarbonization studies, providing a like for like comparison of results to inform gas utility planning and highlight the enduring role of gas infrastructure operators in decarbonized energy systems.

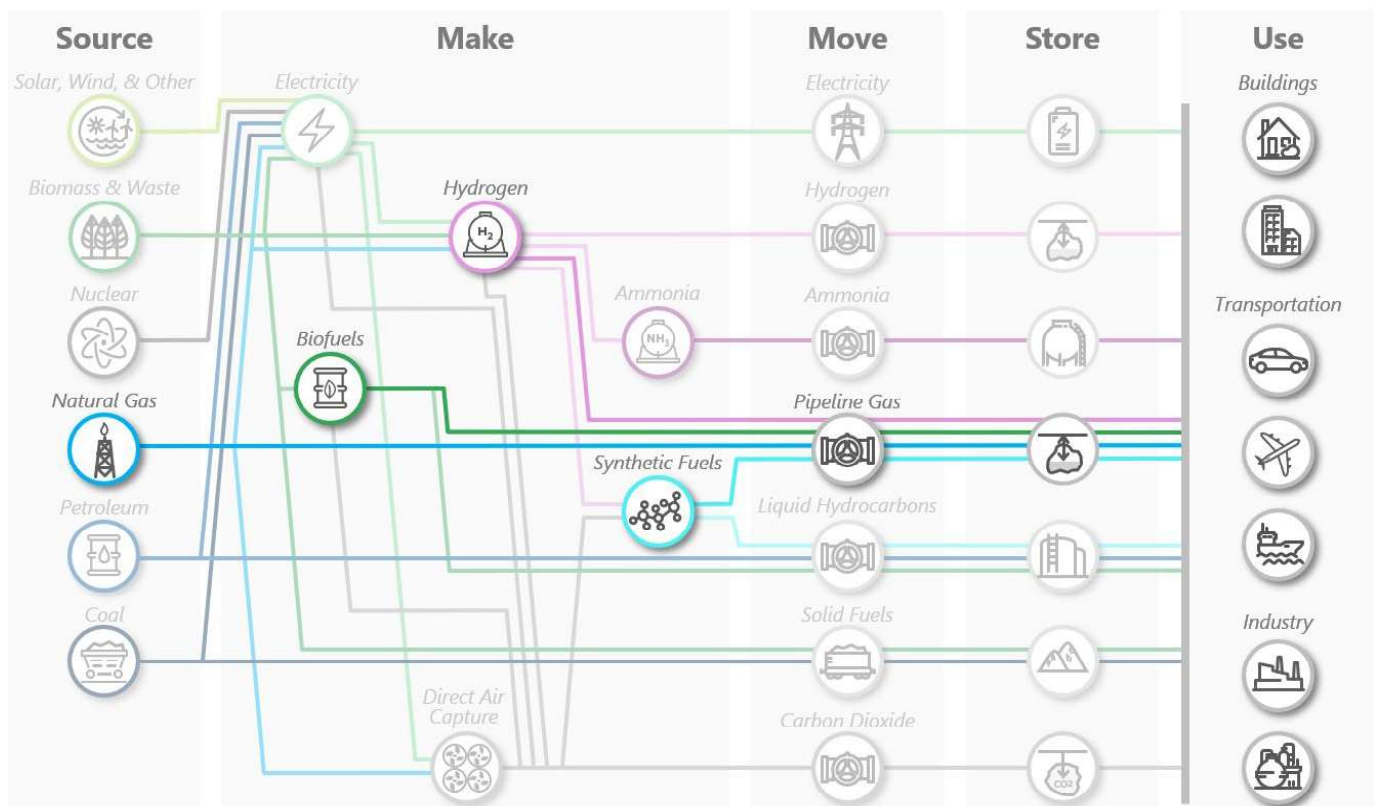
Project Description

This project will perform a recurring meta-analysis across all leading U.S. economy wide decarbonization studies to provide a current, like for like comparison of results, highlighting the role of gas infrastructure operators in decarbonized energy systems. Building on the momentum and methodology established in the initial Meta 1.0 study, which evaluated 23 different decarbonization scenarios across five independent studies, the project will offer an up to date evaluation on the role of gas in decarbonized energy systems, reflecting a new federal administration, new energy demands associated with data centers, and new advancements in technology, policy, and energy systems modeling tools.

This effort is co-funded by an industry research initiative and will lay the foundations for a recurring Meta Biannual study, which will offer ongoing convening and analysis to provide gas utilities with current information and insights in support of long term planning and decision making efforts.

Deliverables

Deliverables for this project include a list of studies reviewed and organized according to screening criteria, a summary set of key findings for the final report, a public report and report launch webinar, and informational toolkit materials including a Catalyst blog post, an in person conference presentation, utility focused and energy systems modeling focused public webinars, and an interview in a relevant energy news publication.



Benefits

This project provides gas infrastructure operators with a current, credible, and comprehensive like for like comparison of results across all leading U.S. economy wide decarbonization studies. By refreshing the meta-analysis with utility stakeholder support and engagement, the study delivers up to date information in support of long term planning and decision making efforts. The detailed assessment of operational patterns for gas infrastructure in these studies helps operators evaluate the associated implications for safety, reliability, and affordability, and elevate credible findings from these studies that point to an enduring role for gas infrastructure.

Technical Concept & Approach

The team will perform a meta-analysis of U.S. economy wide decarbonization scenarios, building on the momentum and methodology established in the initial Meta 1.0 study. The work begins with a landscape assessment of all relevant studies published since August 2023, developing screening criteria and collating publicly available data into a like for like database. Researchers will then engage with the authors of select studies to clarify data interpretation, solicit additional detailed data, and refine and append the database.

This close collaboration with the authors of each of the studies evaluated ensures accurate interpretation of results across several independent studies that encompass a diverse array of perspectives, modeling methodologies, and input assumptions to drive credibility in project outcomes. The team will develop key findings, themes, and takeaways, and hold individual meetings with utility sponsors and stakeholders to present findings and discuss implications for gas utility operations. Throughout the project, researchers will provide a granular interpretation of the role of gas utility operators in deeply decarbonized energy systems, performing a detailed assessment of the operational patterns for gas infrastructure in these studies.

Results

The team developed a three pronged selection criteria for study inclusion: Must Have (U.S. economy wide, deep decarbonization scenario(s); traceability to scenario and results definitions; scenario data published after August 2023); Should Have (economy wide energy systems data/results for 2050); Nice To Have (data for a year prior to 2025 usable for validation of actuals; scenarios incorporating recent trends: IRA, OBBBA, Data Centers). The team reviewed a total of 35 different scenario sets across more than 25 unique decarbonization studies. Of these, 11 scenario sets met the Must Have criteria for inclusion in the meta-analysis, collectively covering a range of U.S. economy wide, deep decarbonization scenarios and providing a robust set of studies for comparative analysis.

The team gathered and processed data from six of the 11 shortlisted scenario sets, spanning multiple modeling frameworks: USREP-ReEDS, Temoa, US-REGEN, EPA-TIMES, GCAM, and MARKAL-NETL. The team established a direct author engagement process to ensure data accuracy and interpretation fidelity across diverse studies.

Status

The project held a kickoff meeting with project sponsors on October 16, 2025, where the team recapped findings from the prior meta-analysis study and engaged in robust dialogue regarding the objectives, scope, and plan for the current effort. Data gathering and processing activities are underway, with six of the 11 shortlisted scenario sets processed. The five remaining scenario sets were identified for completion in Q1 2026. After completing data gathering from the remaining scenario sets, the team will work to harmonize data across studies into a like for like set of results. Ongoing author engagement will continue as needed to clarify data interpretation and obtain additional detailed data that may not be in publicly available datasets.

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Predictive Model for Cross Bore Risk

Researchers will develop predictive cross bore risk models using publicly available information, creating an SME-driven model and a machine learning model to evaluate potential approaches for LDC operations. These geospatial risk ratings will allow utilities to exercise due caution in higher risk areas and strategically prioritize third-party inspections, supporting cost reduction efforts and improving the identification of existing, unknown cross bores.

Project Description

This project will use publicly available information and available cross bore occurrence information to develop predictive models that provide a geospatial risk rating, quantifying the likelihood of a cross bore in a specific location. One model will be derived using LDC subject matter expertise, and another will explore the use of machine learning and AI tools. These models will be evaluated for predictive capability and practical implementation considerations for potential use in LDC operations.

Cross bore incidents pose serious safety risks and impose substantial costs on utilities. Furthermore, third party cross bore inspections are expensive.

Deliverables

Deliverables for this project include a summary of relevant publicly available data sources and supporting documentation, an industry engagement summary, SME-driven model documentation with a summary of model outputs, ML model documentation with a summary of model outputs, and documentation describing developed tools and approaches for cross bore risk prediction.

Benefits

The cross bore risk ratings resulting from this work will provide utilities with valuable knowledge for both identifying existing, unknown cross bores and classifying risk prior to beginning work at a project site. This will allow utilities to exercise due caution in areas of higher risk and support the prioritization of investigations for cross bores in areas of recent work, resulting in more effective third-party investigations.

Cross bores are costly, both from a financial and safety perspective. LDCs can leverage historical data on cross bore incidents to prevent future occurrences and identify the most likely locations of occurrence. Taking precautions to reduce cross bores in higher risk areas will reduce costs and increase safety.

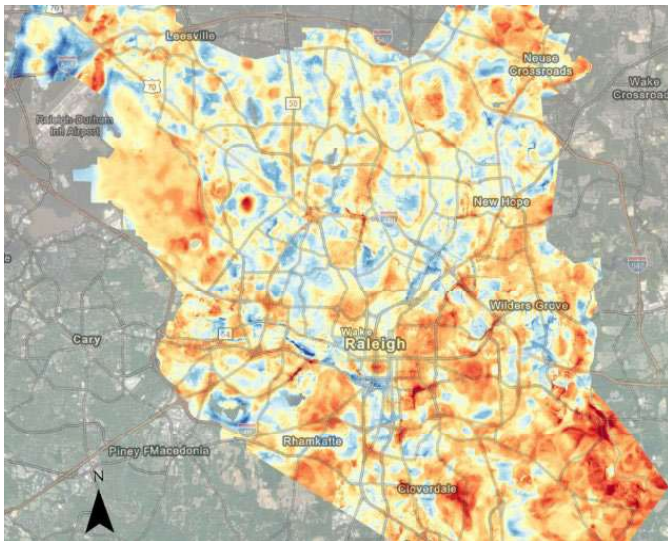
Technical Concept & Approach

The team will develop a cross bore prediction model that provides the probability of a cross bore at a specific location, given information about the infrastructure in the area and the occurrence of cross bores in the vicinity. The project will explore models and methods based on SME knowledge as well as machine learning and AI.

The project will rely on available information from sponsors regarding the occurrence of cross bores in their pipeline network, where such information can be shared. Work will focus on the secure storage, access, and integration of LDC data sources with publicly available data for the respective municipalities. Data processing will maintain data quality, identify errors, and prepare data sets for analysis.

The team will work closely with sponsors to better understand LDC territories and the current processes used to investigate and rank areas at risk for cross bores and will also engage with external





Cross Bore Risk Heat Map - potential visualization

groups that have attempted to address the cross bore problem.

The first predictive model class considered will be based on SME knowledge and understanding, producing baseline models that can be evaluated alongside the machine learning approaches. The second class of models will leverage machine learning (ML), taking variables as potential predictors to evaluate potential predictive capability. The importance of various predictor variables in the ML model may also be compared to the SME-driven model to support discussions regarding potential integration into LDC operating practices.

Results/Status

Over the course of the year, the team worked to advance cross bore risk modeling, with regular coordination with an LDC's subject matter expert (SME). Early efforts focused on documenting existing pre-inspection prioritization practices. As discussions with the SME highlighted persistent post-inspection risks as a primary concern, the project focused on post-inspection prioritization, resulting in the development and execution of multiple post-inspection risk modeling approaches.

The team collected and analyzed post-inspection data from one sponsor detailing which sanitary and storm lines were cleared for the project areas investigated in 2024. Another sponsor offered data that could be used to assess pre-inspection risk in

areas, though the data were less rich; the project team started with the first sponsor, with plans to follow up with the second.

The team developed a structured suite of SME based risk models encoding known cross bore risk drivers: installation method and era, pipe material, contractor history, and environmental context such as road crossings and population density. The risk metrics span from simple binary eligibility screens to fully proportional formulations that allow risk to vary smoothly across mixed practice project areas.

The team designed a data driven model for post-inspection prioritization to quantify the probability that cross bores remain in a project area after inspections. Models were developed at either a project scope level or at the level of individual gas-sewer/storm collision points. The model at the individual collision point level integrates inspection outcomes (cleared vs. uninspected) with select covariates derived from public data sources such as slope and population density, producing probabilistic risk scores that direct remaining investigation effort to locations most likely to still contain cross bores.

Initial analysis identified that the sponsor provided post-inspection storm/sewer line data includes only a limited set of covariates for modeling. Four post-inspection risk metrics were created and demonstrated on a combination of real and synthetic data. Additional publicly available data or more detailed data from LDCs are required for improving the explanatory and predictive power of the models.

The project team convened a sponsor update meeting to present the post-inspection risk models and summarize the results generated to date. In parallel, the team engaged any additional sponsors willing to share their data, using these discussions to evaluate how effectively the models leverage sponsor specific datasets and to gather feedback on refinements needed to ensure the tools meet diverse operational needs.

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