

METHANE MITIGATION TECHNOLOGIES PROGRAM

Mountain Valley Pipeline, West Virginia

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The U.S. Department of Energy's (DOE) Office of Fossil Energy and Carbon Management's (FECM) Methane Mitigation Technologies Program (MMT) is pursuing research to quantify and mitigate methane emissions throughout the natural gas upstream and midstream infrastructure. FECM plans to advance cost-effective technologies that detect, measure, predict and prevent methane leaks more efficiently and improve the availability and reliability of methane emissions data across the entire fossil energy value chain. Enhanced understanding of the potential size and distribution of methane leak rates will advance the scientific basis for technology development efforts to reduce impacts on the environment associated with natural gas and oil operations and has the potential to offset practices such as routine natural gas flaring. Research into emissions quantification and mitigation technologies will also help accelerate the commercial availability of cost-effective products and procedures for reducing methane emissions in manner that is aligned with the DOE strategy, Administration policies, Congressional funding appropriations and emerging regulatory developments.

The United States is fortunate to have a significant natural gas resource base, estimated at 3,368 trillion cubic feet (technically recoverable) as of year-end 2020. In addition, the volume of natural gas transported through midstream infrastructure has increased nearly five-fold since 1950 and is expected to increase by another 22% by 2040. In 2019, a volume of 1.48 billion cubic feet per day (Bcf/d) of natural gas was intentionally vented or flared by operators at well sites due to operational, safety, or economic reasons. This volume represents the highest amount since 1961 and has a value estimated at more than \$2 billion based on the annual average city gate natural gas price. NETL's Methane Mitigation Technologies Program accelerates the development of new tools, technologies and processes that can help industry adopt "next generation" facilities, equipment and components that will conserve natural gas, reduce methane emissions, improve transportation efficiency and enable the beneficial use of underutilized gas sources such as gas that is being flared. The Methane Mitigation Technologies Program is proceeding along several parallel paths in methane emissions quantification and emissions mitigation:

- Improve capabilities for detecting and monitoring inadvertent and operational methane emissions across the oil, natural gas and renewable natural gas production processing, transportation and storage sectors through the development of improved sensors, low-cost leak indicators and more accurate remote sensing methods.
- Develop rigorous basin scale field assessments to reconcile the differences between bottom-up engineered estimates based upon equipment counts and emission factors compared to top-down satellite and atmospheric estimates.
- Develop more accurate and representative methane emissions factors and more effective lower-cost retrofits of equipment components prone to leaks or chronic emissions such as pneumatic valve controllers, compressor seals and packing, natural gas fired engines and distribution lines.
- Generate fundamental knowledge and develop new technologies and methodologies for enabling the wider application of "smart" systems within the U.S. natural gas infrastructure to improve risk assessment, safety, reliability and operational efficiency.
- Develop initial planning and future expansion for an Integrated Methane Measurement, Monitoring, and Characterization Platform (IMMMCP) as a low-cost, efficient, accurate, implementable and maintainable system to enable early detection, notification and real-time quantification of methane emissions across the oil and natural gas supply chain.



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- Employ improved methods for locating, quantifying and mitigating methane emissions from both active and abandoned infrastructure elements such as coal mines, undocumented wells and their associated infrastructure to prioritize their management and plugging.
- Develop strategies for eliminating natural gas flaring through advanced processing and conversion technologies, pilot-scale systems and pre-commercial validation of full systems designed to eliminate flaring through the onsite manufacturing of chemicals or by ensuring the destruction efficiency targets are met when flaring has to be used.



Bradshaw Compressor Station, Wetzel County, WV (2017)

NETL'S RESEARCH WILL IMPROVE EFFORTS TO PROTECT THE ENVIRONMENT BY INVESTIGATING TWO MAIN AREAS:

EMISSIONS QUANTIFICATION

DETECTION AND MEASUREMENT TECHNOLOGIES — Develop continuous, surface-based and aerial gridded monitoring of methane emissions that can quickly detect and identify chronic and acute emissions to inform mitigation efforts and support emission inventories.

PILOT & FIELD DEMONSTRATIONS — Complete testing and demonstration of real-time autonomous methane detection and monitoring systems at pilot scale in the field to validate pre-commercial operation, accelerate deployment and build industry acceptance.

MULTI-SCALE EMISSION SOURCE CHARACTERIZATION — Implement a multi-tiered top-down and bottom-up approach to improve the accuracy of methane emission assessments along the natural gas supply chain over wide spatial areas and across large time scales.

INTEGRATED METHANE MONITORING TECHNOLOGIES — Develop robust integrated detection and monitoring systems to track methane emissions nationwide caused by super emitter malfunction events and chronic background emissions from collections of smaller point sources.

EMISSIONS MITIGATION

EMISSIONS REDUCTION TECHNOLOGIES — Develop technologies applicable across all sectors through retrofits or upgrades to regularly emitting devices such as compressors and natural gas-fired engines.

LEGACY EMISSIONS - UNDOCUMENTED ORPHANED WELLS — Develop technologies and processes for effective identification of undocumented orphaned wells (UOWs), characterization of the emissions from the wells and infrastructure and development of new characterization concepts and advanced materials for more efficient and cost-effective permanent plugging and abandonment (P&A).

STRANDED AND UNDERUTILIZED NATURAL GAS CONVERSION — Develop modular, flexible and adaptable technologies for stranded or underutilized natural gas using novel catalysts, equipment and processes that enable well site gas processing and chemical conversion to marketable chemicals, as well as improved ultra-high destruction efficiency flares for cases where flaring is the only technically feasible option.

TECHNOLOGY PARTNERSHIPS

The Pipeline and Hazardous Materials Safety Administration (PHMSA) of the U.S. Department of Transportation, manages a research program that includes efforts to detect internal pipeline defects associated with methane leaks in pipelines. Furthermore, within DOE, ARPA-E has several research projects focused on the development of infrared and spectrometry-based sensors for detecting and quantifying methane leaks from natural gas production sites.

A multi-agency working group is seeking to develop a comprehensive, nation-wide methane monitoring, measurement, recording and verification (MMRV) system that combines U.S. capabilities and expertise in greenhouse gas emissions and removal measurements, analysis and modeling across numerous U.S. Agencies, the private sector and academia. Bottom-up component-based assessments include the EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks where DOE is supporting enhancement of the accuracy of emissions estimates from upstream oil and natural gas production operations.

Data gaps and R&D needs related to undocumented orphaned wells are being addressed through active collaboration between DOE, the Interstate Oil and Gas Compact Commission (IOGCC), the Department of the Interior (DOI), state regulatory agencies and industry stakeholders. The focus has centered around efficient determination of well location, the development of minimally invasive techniques to characterize well construction and mechanical integrity, sensor and data acquisition and risk assessments.

The National Energy Technology Laboratory is a U.S. Department of Energy national laboratory that drives innovation and delivers technological solutions for an environmentally sustainable and prosperous energy future. Through its world-class scientists, engineers, and research facilities, NETL is ensuring affordable, abundant, and reliable energy that drives a robust economy and national security, while developing technologies to manage carbon across the full life cycle, enabling environmental sustainability for all Americans, advancing environmental justice and revitalizing the economies of disadvantaged communities.

NETL lends its expertise toward achieving a carbon-free power sector by 2035 and a net-zero economy by 2050 while catalyzing economic revitalization, creating good-paying jobs and supporting workers in energy communities, especially hard-hit coal, oil and gas, and power plant communities across the country. One of the most rewarding aspects of NETL's research is that our innovations and technologies have the potential to improve people's lives in meaningful ways.

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