TESTIMONY OF DR. BRIAN ANDERSON

DIRECTOR OF THE NATIONAL ENERGY TECHNOLOGY LABORATORY

U.S. DEPARTMENT OF ENERGY

BEFORE THE

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

ON

DETECTING AND QUANTIFYING METHANE EMISSIONS FROM THE OIL AND GAS SECTOR

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Chairwoman Johnson, Ranking Member Lucas, and distinguished members of the Committee on Science, Space, and Technology, thank you for the opportunity to discuss methane research and development (R&D) today. My name is Dr. Brian Anderson, and I am the Director of the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL).

NETL has three R&D campuses located in Morgantown, West Virginia; Pittsburgh, Pennsylvania; and Albany, Oregon. NETL also operates field offices in Anchorage, Alaska, and Houston, Texas. The mission of NETL is to drive innovation and deliver solutions for an environmentally sustainable and prosperous energy future, ensuring affordable, abundant, and reliable energy that drives a robust economy and ensures national security while developing technologies to manage carbon across the full life cycle and enabling environmental sustainability for all Americans.

To help lead a clean energy revolution that achieves a carbon pollution-free power sector by 2035 and put the United States (U.S.) on an irreversible path to a net-zero economy by 2050, NETL is accelerating technologies to decarbonize power generation and industrial sources, remove carbon dioxide (CO2) from the atmosphere, and mitigate environmental impacts from fossil fuels. Essential technology in the Administration's plan to decarbonize the economy is the production of carbon-free hydrogen and ammonia. Where hydrogen and ammonia production relies on the existing natural gas production and distribution assets, therefore, reducing methane emissions in the oil and gas sector represents an opportunity to achieve four goals: 1) stabilize the climate by taking cost-effective steps to tackle the serious near-term threat of methane, a potent greenhouse gas accounting for about half of the rise in global average temperature since the pre-industrial era; 2) keep communities free from contamination of their water and air supplies; 3) advance American technology to address decarbonization, and 4) create jobs. These efforts inform and support efforts throughout the U.S. government to reduce carbon emissions in the oil and gas sector and beyond.

As outlined in the Office of Fossil Energy and Carbon Management's (FECM) Strategic Vision, NETL is supporting research to address mitigation and quantification of methane emissions from fossil energy supply chains—from resource production, processing, transportation, utilization, and storage—and developing accurate, cost-effective, efficient technology solutions and best practices to identify, measure, monitor, and reduce methane emissions from these sources.

NETL's Cutting Edge Research to Quantify and Reduce Methane Emissions

NETL's in-house R&D programs pursue integrated laboratory and field-based research focused on emissions mitigation and quantification. The lab leads its technology development with systems engineering and analysis and full life cycle analysis to assess low-cost and clean development pathways and strategies.

Orphaned Oil and Gas Wells

The number of orphaned wells across the U.S., many of which were drilled before regulatory standards were enacted, is estimated to be between 90 thousand and 130 thousand. NETL is working to bridge the knowledge gap and develop cost-effective methods for locating undocumented orphaned oil and gas wells, quantifying their emissions in order to prioritize their management for plugging. For example, since 2005, NETL has developed rapid airborne methods for locating undocumented orphaned wells through the development and field validation of advanced electromagnetic hardware and machine learning software.

Emissions Quantification and Mitigation Using Life Cycle Analysis (LCA)

For the last decade, NETL has served as FECM's national expert in evaluating and communicating life cycle environmental information (based on the current state of knowledge) to internal and external stakeholders for them to gain an understanding of the natural gas extraction, delivery, and electricity production landscape. NETL continues to develop more accurate and representative quantification of methane emissions factors for specific equipment components across the U.S. Greenhouse gas (GHG) emission quantification and mitigation are two complementary tactics that make up a more comprehensive strategy for decarbonizing the natural gas systems.

NETL research shows how methane emission quantification is necessary to develop effective emission mitigation strategies that increase natural gas supply chain efficiency while reducing methane emissions. Compressors, pneumatic devices, and equipment leaks are the top three *methane* emitting sources from the natural gas supply chain. NETL researched methane mitigation strategies in the natural gas sector to quantify and identify reduction opportunities from extraction of natural gas to delivery to the end use customer. Methane mitigation solutions need to be tailored to regional operating characteristics of the natural gas value chain to prioritize strategic investments and actions.

As an example of a successful government and industry collaboration, NETL led an effort to improve the quantification of methane emission across the natural gas supply chain to assess technically and economically viable solutions for decarbonization. The Our Nation's Energy Future (ONE Future) natural gas industry partnership collaborated to assess the greenhouse gas emission profile and methane emission rates representative of ONE Future's supply chain and compared them to the emission profile and emission rates for the U.S. natural gas supply chain.

NETL uses LCA as a tool and framework to inform and drive R&D decisions and identify emissions across the supply chain.

Sensor Devices and Enabling Technologies

Pipelines are static components in the natural gas system. Currently, most pipelines deliver gas from one point to the next with no way to monitor conditions/performance along their lengths. Low-cost, low-maintenance pipeline sensor technologies can monitor corrosion rates, gas leaks, and gas stream chemistry and enable a more intelligent natural gas infrastructure. NETL is developing methods for interrogating the sensors via wireless telemetry, test procedures for effectively embedding sensors in coated pipe, and conduct field-based tests of pipeline monitoring systems to verify performance. Field validation and testing of new sensors and data analytic methods, including machine learning and artificial intelligence (ML/AI), pursued as the various technologies mature.

Pipeline Material Technologies

NETL is developing advanced pipeline materials for corrosion-protection systems that can accommodate multi-gas streams and real-time sensor technology that can enable gas composition monitoring in real time. Researchers are optimizing materials based on leak prevention performance and sensor technologies based upon the need for multicomponent speciation and/or distributed interrogation capability. These corrosion control systems are needed on both existing and new transmission pipelines.

Advanced Data Analytics

NETL's expertise in developing geo-data science, visualization, online data mining and integration, and advanced analytics through scientific computing and virtualized environments can be leveraged to support innovative analytics for the methane mitigation and quantification. NETL's established scientific computing facilities and competencies include: the high-performance computing cluster (Joule), ML computing cluster (Watt), and Energy Data eXchange (EDX®).

Advanced data analytic approaches will also be integrated into new sensor technology applications, including ML/AI, coupled with distributed optical fiber sensor for diagnosing internal and external hazards, defects, corrosion, and even real-time operational conditions of natural gas pipelines. Such advanced analytics have the potential to identify early sources of catastrophic pipeline failure prior to an event occurring to enable preventative action, as well as enable an understanding of real-time operational parameters, which can be used to maximize efficiency and ensure cyber-physical security of the natural gas pipeline infrastructure.

Non-Combustion Methane Utilization

NETL has developed and demonstrated new materials and methods that use excess electricity to convert methane, CO_2, and water into chemical building blocks and emerging energy carriers, such as hydrogen, carbon monoxide, and formic acid. These inventions will allow the development of modular reactors that use intermittent renewable electricity to produce carbon-negative commodity chemicals. Microwave reactors also provide process intensification that allows economically viable operation of traditionally energy intensive processes. For example, microwave dry reforming of methane produces H_2 and CO, and consumes 11 tons of CO_2 for every ton of H_2 produced, whereas a traditional steam reforming process to convert methane into H_2 produces approximately 10 tons of CO_2 for every ton of H_2.

FECM's Office of Resource Sustainability

In addition to NETL's in-house R&D programs, the lab supports and implements FECM's Office of Resource Sustainability. NETL partners with industry, academia, technology developers, government agencies, and other national laboratories to ensure the effectiveness and efficiency of research projects throughout its portfolio. NETL also utilizes field laboratories as a mechanism to establish collaboration for validation of innovative technologies that will maximize the safe, efficient, and economic recovery of America's abundant oil and gas resources.

Cutting-edge research in Methane Emissions Quantification

Research for Methane Emissions Quantification focuses on developing technologies to detect, locate, and measure emissions. This includes validating the performance of new technologies that are intended to more accurately and precisely measure emissions occurring within the natural gas chain. More specifically, research includes advancing external leak detection and rate quantification, developing direct and remote measurement sensors, and engaging in field efforts to characterizing emissions.

NETL is working to collect and evaluate representative, defensible, and repeatable methane emissions data from marginal well sites at various basins across the U.S. to accurately draw quantifiable conclusions that can be compared to published data available on the emissions from non-marginal wells. A robust assessment of methane emissions from marginal vs. non-marginal well sites based on the quantity and condition of equipment and components within these populations and related operational information will inform mitigation strategies for the minimization of environmental impacts of fossil fuels while working towards net-zero goals.

NETL is also collaborating with the Colorado State University, Harrisburg University, University of Texas (UT) at Arlington, and UT at Austin to implement a comprehensive process of protocol development and testing to accelerate the adoption of natural gas leak detection and quantification solutions by natural gas operators, and their approval by cognizant regulatory authorities. Known as the Methane Emissions Testing and Evaluation Center (or METEC), this project is developing the testing, analysis, and adoption protocol for leak detection and quantification solutions will inform mitigation strategies to minimize the environmental impacts of fossil fuels.

Cutting-edge research in Methane Emissions Mitigation

The Methane Mitigation Technologies program is focused on developing, modifying, and evaluating cost-effective and state-of-the-art tools, technologies, and materials to mitigate methane emissions from the entire natural gas value chain. The program also seeks to efficiently and economically convert associated gas at the wellhead into higher-value products that can be more readily brought to market than the natural gas itself and eliminate the need for flaring. Methane mitigation R&D efforts include advanced materials of pipeline construction, monitoring sensors, data management systems, and more efficient and flexible compressor stations.

NETL is partnering with the Gas Technology Institute (GTI) and the UT at Austin to design, build, and test an innovative, high-pressure compressor designed to recover methane leaks within the natural gas transmission system. The unique design will enable the compressor to function under a broad range of pipeline operating conditions and to reach the high discharge pressures required for gas recovery.

Capturing emissions from this area of the natural gas network could reduce methane emissions up to 20%.

NETL is collaborating with the University of Tulsa and the University of Oklahoma to develop advanced natural gas flow controllers (pneumatic controllers) capable of self-healing/repair functionality when combined with a low-cost leak detection sensors. The technology is demonstrating reduction of leak rate by at least 80% compared to a non-healing control in commercial valve.

Conclusion

Methane mitigation has an immediate impact due to methane's especially large short-term warming impacts, with a long-term pathway to unlocking technologies for other GHG management beyond the fossil sector. NETL is pursuing FECM's strategic vision to minimize emissions of methane during production, processing, transportation and use across the coal, oil and gas industry, eliminating non-trivial methane emissions from carbon-based fuel supply chains by 2030.

Through in-house research, partnerships with industry, universities, and other national labs – and of course, Federal investments – it will continue to drive the commercialization of products and processes that achieve U.S. and international decarbonization goals while supporting job creation and global competitiveness as the world's energy transition proceeds.

Thank you for the opportunity to discuss some of these cutting-edge innovations to mitigate methane emissions, which have applications within – and beyond – the energy sector.

Brian J. Anderson, Ph.D.

Director
National Energy Technology Laboratory
U.S. Department of Energy

NATIONAL ENERGY TECHNOLOGY LABORATORY

As director of the National Energy Technology Laboratory (NETL), Brian J. Anderson, Ph.D., manages the complete NETL complex, including delivery and execution of the Laboratory's mission and national programs in carbon-based energy and program support to the U.S. Department of Energy (DOE) Offices of Energy Efficiency and Renewable Energy; Electricity; and Cybersecurity, Energy Security and Emergency Response. Anderson leads NETL's more than 1,300 employees and guides more than 1,000 R&D projects in 50 states with a total award value of $5 billion. As director, Anderson fosters strategic relationships with utility and academic institutions, state and local governments, and important carbon management stakeholders. Under Anderson's leadership, NETL initiated critical technology development and deployment projects including direct air capture technologies for decarbonization, chemical looping combustion with potential to reduce greenhouse gas emissions, and non-variable renewable energy for future low-carbon power systems. Anderson also guided the development and maturation of key technologies proven to have significant industry impact including microwave ammonia synthesis and carbon nanomaterials manufactured from coal. In April 2021, the Biden Administration named Anderson executive director of the Interagency Working Group on Coal and Power Plant Communities and Economic Revitalization. In this role, Anderson strategically leverages NETL's resources and expertise to help ensure the shift to a clean energy economy creates good-paying union jobs, spurs economic revitalization, remediates environmental degradation and supports energy workers in coal, oil and gas, and power plant communities across the country.

Anderson is the recipient of the 2020 Federal Laboratory Consortium Laboratory Director of the Year award, and Secretary's Honor Award and Presidential Early Career Award for Scientists and Engineers for his research. Anderson earned his bachelor's degree in chemical engineering at West Virginia University and his master's and doctorate in chemical engineering from the Massachusetts Institute of Technology.