Cutting Methane Pollution:
Safeguarding Health, Creating Jobs, and Protecting Our Climate

A Hearing of the
Select Committee on the Climate Crisis
United States House of Representatives

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The Testimony of
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Chairwoman Castor, Ranking Member Graves, and distinguished Members of the Committee, thank you for inviting LongPath Technologies to testify today. My name is Caroline Alden. I have spent the last 15 years using greenhouse gas measurements to understand emission sources and sinks to the atmosphere. After a decade contributing to academic research on this topic, I co-founded and am now the Vice President of Product and Markets for LongPath Technologies. In this role, I not only work on the algorithms to leverage atmospheric measurements to monitor methane emissions, but I also work with experts and stakeholders across industry, academia, environmental organizations, and government.

This morning I look forward to discussing both the technology and benefits of measuring and mitigating methane emissions from oil and gas operations and other man-made sources. In the oil and gas industry, where LongPath provides methane monitoring, reducing emissions is a win-win for the climate, for industry, for neighboring communities, and for policymakers who are concerned about methane pollution.

Methane leaks from oil and gas operations are unpredictable. They can happen anywhere and at any time, and they can also be intermittent, meaning leak sizes can change over hours or days.[1] Finally, methane leak plumes are invisible and odorless. These characteristics make leaks of methane from oil and gas operations very difficult to catch without advanced technologies.

[1] Cusworth, D.H., Duren, R.M., Thorpe, A.K., Olson-Duvall, W., Heckler, J., Chapman, J.W., Eastwood, M.L., Helmlinger, M.C., Green, R.O., Asner, G.P. and Dennison, P.E., 2021. Intermittency of large methane emitters in the Permian Basin. *Environmental Science & Technology Letters*, *8*(7), pp.567-573.

There are three pillars of advanced methane detection:

1. **Frequency of data readings.** Total emissions are the leak rate times how long the leak goes on, meaning the faster you catch it the better. And intermittent emissions are hard to catch at all without high-frequency data.
2. **Site coverage.** It's important to see all emission points on a site. The older EPA method of using handheld infrared cameras often misses unlit flares, for example, because they are high up off the ground.
3. **Sensitivity to different leak sizes.** Can a technology catch all leaks or only large leaks? As industry keeps reducing emissions, technologies must ultimately be able to help operators get to zero emissions. That means seeing both large and small leaks is important.

There is a wide range of new methane detection technologies. Airplanes and satellites generally perform periodic surveys of sites. Aerial surveys see all equipment on a site, but generally only catch larger leaks. However, by covering large areas, aerial surveys provide important information about what emissions look like as a whole, including whether policy targets are being met.

Fixed, continuous monitors provide a high frequency of readings. This characteristic allows for reliable and rapid fixing of leaks. LongPath's laser fencelines provide full site coverage, including of tall equipment like stick flares. While other continuous technologies vary in terms of site coverage, many are able to catch small leaks, and many have the ability to *quantify* leak rates.

The US doesn't currently have a regulatory system established to leverage quantification data. However, quantitative data provides many benefits. Quantification lets operators prioritize leaks for repair, gauge the cost-effectiveness of equipment replacements, tune equipment set points to lower emissions, track how equipment performs in different settings, and, ultimately, assess how well compliance measures work.

The LongPath network is a little like a methane radar. We use Nobel prize-winning frequency comb lasers that emit hundreds of thousands of colors of infrared light. We measure methane and other greenhouse gasses by detecting how much of that light is absorbed while it is traveling through the atmosphere. The laser is tower-mounted, and each tower covers 20 square miles, measuring emissions on a site-by-site basis for customers within the purview. The ability to provide broad-scale network style coverage means that there is a very low barrier to entry for monitoring all types of facilities including, importantly, marginal well sites.[2][3]

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[2] Bowers, Richard L. *Quantification of Methane Emissions from Marginal (Low Production Rate) Oil and Natural Gas Wells*. United States: N. p., 2022. Web. doi:10.2172/1865859.

[3] Omara, M., Zavala-Araiza, D., Lyon, D.R., Hmiel, B., Roberts, K.A. and Hamburg, S.P., 2022. Methane emissions from US low production oil and natural gas well sites. *Nature communications*, *13*(1), pp.1-10.

Going back to those pillars of advanced monitoring: LongPath provides continuous, quantitative emissions data to customers in real-time; our data provides full coverage of all equipment on site; and we have a very sensitive ability to see leaks - 10 to 1000 times more sensitive than aerial and satellite technologies. Importantly, the tech is proven through extensive 3rd-party blind testing at test sites[4] and in the field, and we have made that data publicly available.[5][6]

I'd like to offer 4 themes for methane detection in emerging policy, differentiated markets, and industry adoption:

1. Methane monitoring reduces emissions, saves costs for operators, drives energy efficiencies for the market (extending all the way to the ratepayer), and creates jobs. LongPath has tripled in size in the last year, with new jobs ranging from field technicians in West Texas to software engineers working remotely across the US.
2. The US is the world leader in methane monitoring technologies. If we recognize the aligned incentives of policy makers, climate advocates and industry, then US gas can also become the cleanest in the world. To accomplish this, policies and regulations should encourage operators to use new technologies and also plan for quantification and performance-based metrics. EPA rules should include new technologies in a matrix that allows for technology-neutral choices by operators. SEC rules should require measurements, not outdated inventories. And responsibly sourced gas standards should preclude greenwashing by driving stringency, transparency and quality in monitoring.
3. The federal government should invest in the creation of independent third-party bodies to create standards for certifying the capabilities of new alternative technologies.
4. Finally, continuous monitoring is inexpensive and more than pays for itself through increased efficiencies for the oil and gas industry. Reduced costs and revenue retention for operators occur in two ways: by fixing leaks and equipment malfunctions, and by providing real-time feedback on operations. Not to mention the co-benefits of cleaner air, a more stable climate, jobs creation and American leadership in environmental standards and technological innovation. As my colleague Greg Rieker said two weeks ago in testimony to the House Science Committee, we can outfit the Permian Basin for continuous, quantitative methane emissions monitoring for less than the cost of 20-30 miles of interstate highway, or, as he put it, for less than the cost of the last James Bond movie.

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[4] Methane Emissions Technology Evaluation Center (METEC): https://energy.colostate.edu/metec/

[5] Alden, C. B., Coburn, S., Wright, R. J., et al. (2019). Single-blind quantification of natural gas leaks from 1 km distance using frequency combs. *Environmental Science & Technology*, *53*(5), 2908–2917. https://doi.org/10.1021/acs.est.8b06259

[6] Coburn, S., Alden, C. B., Wright, R., et al. (2020). Long distance continuous methane emissions monitoring with dual frequency comb spectroscopy: deployment and blind testing in complex emissions scenarios. https://arxiv.org/abs/2009.10853

Summary information on LongPath Technologies

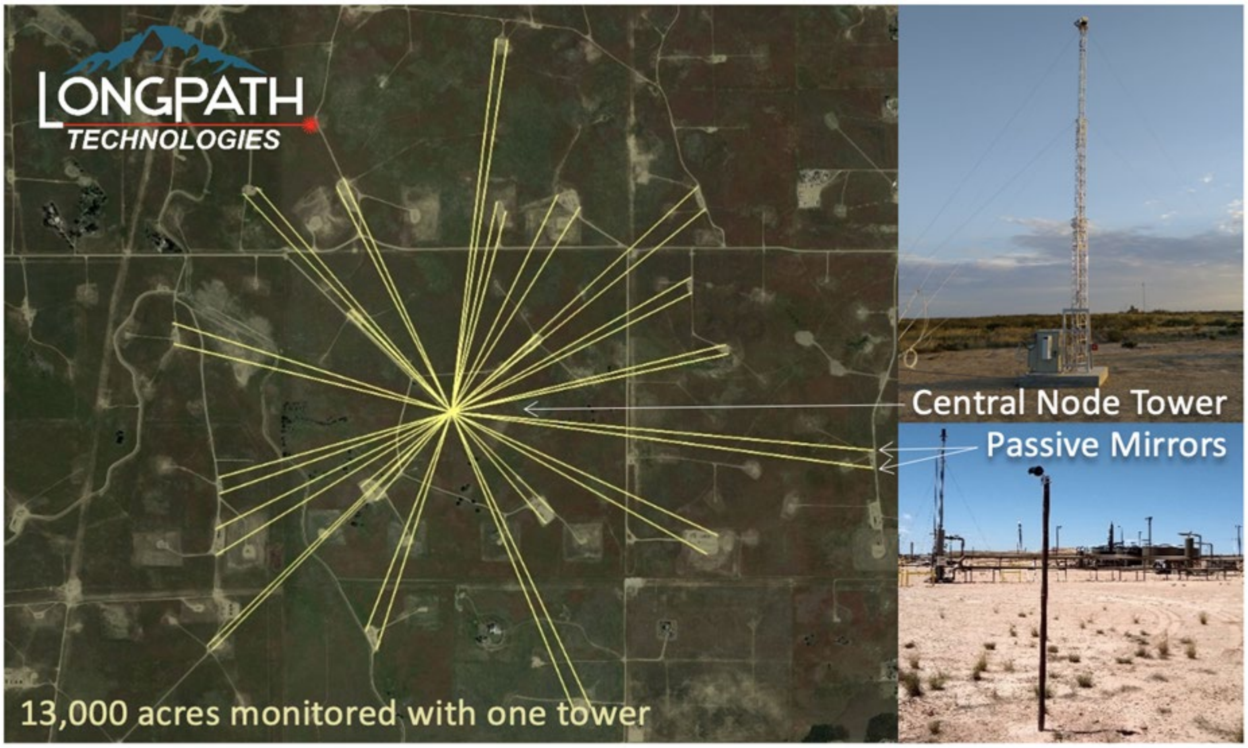
The LongPath system is a fixed-location continuous monitoring system. The LongPath monitoring system employs dual frequency comb spectrometer (DCS) technology with a detection range of up to 5 km. The LongPath system is capable of continuously monitoring multiple facilities via a single installation of a centralized tower from which the laser light source is generated. The high site coverage of a single reading, combined with high frequency of data collection and low detection threshold, classify this technology as "true continuous". The LongPath system employs a rigorous system of quality control checks to ensure incoming data is valid. With this data, the LongPath system is capable of accurately quantifying emission rates with a detection and quantification level of 0.2 kg/hr. Time-to-detect of emission from leak start to leak detection for sustained emissions ranges from several minutes to less than one day.

LongPath's DCS technology was developed at the National Institute of Standards and Technology (NIST) and the University of Colorado Boulder and was transitioned for field use and oil and gas monitoring by LongPath's founders at the University of Colorado under the Department of Energy's ARPA-E MONITOR program. Open-path, laser-based DCS measurements rely on frequency combs, a specialized class of lasers that output hundreds of thousands of stable, discrete wavelength elements or "comb teeth"; an innovation that garnered the Nobel Prize at the University of Colorado in 2005. DCS leverages these properties to enable spectroscopic measurements at an unprecedented combination of spectral bandwidth (>100 nm), resolution ($<2\times10^{-3}$ nm) and signal-to-noise ratio, providing precise and accurate absorption spectra that yield high-fidelity, multi-species measurements.[7][8]

The LongPath system is composed of a 50-foot-tall retractable tower on an approximately 8-foot square base, where a field hardened control cabinet houses LongPath's proprietary laser spectrometer and computing and control systems. A telescope, which emits the laser light and receives (detects) the reflected, return laser light, sits at the top of the tower. The control cabinet, tower, and an anemometer are all co-located at a central node. Fetroreflectors are installed on and/or around each monitored area and return emitted laser light to the transceiver.

[7] Rieker, G. B., Giorgetta, F. R., Swann, W. C., Kofler, J., Zolot, A. M., Sinclair, L. C., … Newbury, N. R. (2014). Frequency-comb-based remote sensing of greenhouse gases over kilometer air paths. Optica, 1(5), 290–298. https://doi.org/10.1364/OPTICA.1.000290

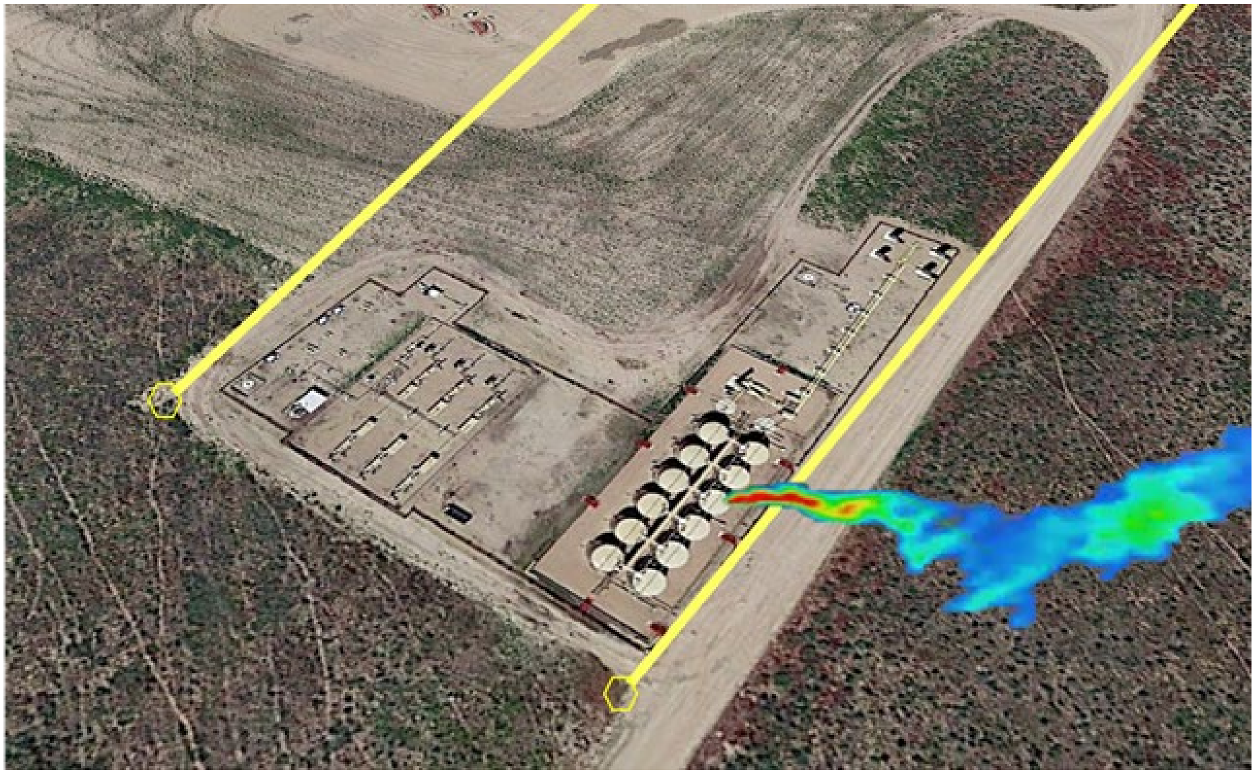
[8] Coburn, S., Alden, C. B., Wright, et al., (2018). Regional trace-gas source attribution using a field-deployed dual frequency comb spectrometer. *Optica*, *5*(4), 320. https://doi.org/10.1364/OPTICA.5.000320



LongPath System deployment overview. A central node is shown in the center of the starburst pattern in the left-hand panel. In that panel, yellow lines indicate the geometry of eye-safe and invisible laser light that travels between the telescope (located at the central node location) and retroreflective mirrors (or "passive mirrors") located in and around monitored areas.

Measurements are coupled to an atmospheric model and methane source sizing/localization inversion framework. LongPath positions laser beams to create a fenceline around each monitored area and measures plumes as they cross the beamline. The sensor geometry for LongPath is not a single point in space, but, instead, an integrated line (pathway) through space between the telescope head and the retroreflective mirror (and back). LongPath's full fenceline attribute results in high spatial coverage of the monitored area with each reading that is taken under a wide range of wind directions.

LongPath has demonstrated in blind testing (METEC and field) the ability to detect, locate, and quantify methane sources from individual facilities at rates of 0.2 kg/hr over large regions.[9][10][11][12]



Laser beam paths (yellow lines) extend between the telescope (outside image top) to retroreflector locations (yellow hexagons), providing a fenceline bounding the monitored area. Sites are measured during wind conditions that favor high site coverage (potential plumes would cross bounding laser beams). A theoretical plume is shown emitting from the tanks and crossing the downwind beam.

Importance of Continuous Monitoring

The benefits of continuous monitoring are many and impact many stakeholders: neighboring communities in oil and gas production areas, the environment and global communities grappling with a changing climate, and an industry that is working to reduce waste and cut emissions.

[9] Rieker, G., et al., (2014). Frequency Comb-Based Remote Sensing of Greenhouse Gases over Kilometer Air Paths, Optica, 1, 290-298. https://doi.org/10.1364/OPTICA.1.000290

[10] Coburn, S., Alden, C. B., Wright, et al., (2018). Regional trace-gas source attribution using a field-deployed dual frequency comb spectrometer. Optica, 5(4), 320. https://doi.org/10.1364/OPTICA.5.000320

[11] Alden, C. B., Ghosh, S., Coburn, S., et al. (2018). Bootstrap inversion technique for atmospheric trace gas source detection and quantification using long open-path laser measurements. Atmospheric Measurement Techniques, 11(3), 1565–1582. https://doi.org/10.5194/amt-11-1565-2018

[12] Alden, C. B., Coburn, S., Wright, R. J., et al. (2019). Single-blind quantification of natural gas leaks from 1 km distance using frequency combs. Environmental Science & Technology, 53(5), 2908–2917. https://doi.org/10.1021/acs.est.8b06259

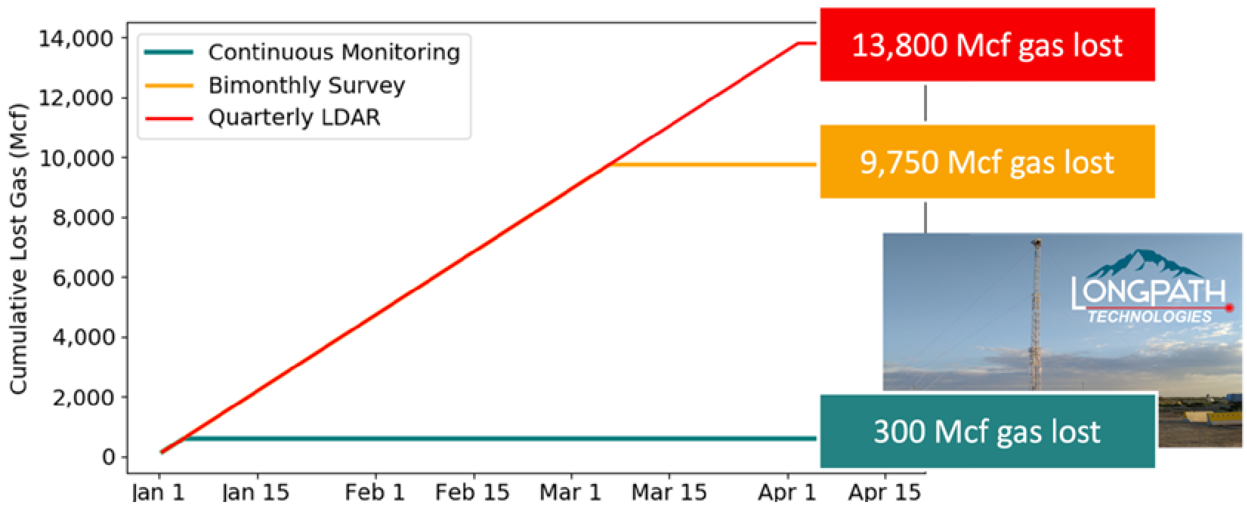
Methane emissions from oil and gas are intermittent and vary through time, at both producing and abandoned well sites,[13][14] with intermittent emissions contributing substantially to overall emissions. Continuous monitoring is therefore unparalleled in the value it provides. Snapshot monitoring approaches (OGI, aircraft, satellite surveys) can't provide adequate information for operators to mitigate, or often even detect, intermittent emissions. Continuous monitors can mitigate intermittent emissions by revealing temporal context about deviations from baseline rates, which can be linked with SCADA data for root cause analysis. Off-site diagnosis and even repair can often be accomplished. Further, continuous monitors don't mistake intermittent emissions for persistent emissions, as can be the case for snapshot-in-time surveys (resulting in wasted OGI follow-ups).

The temporal context and coverage provided by continuous monitors also means that leak repairs can be immediately verified without site visits or OGI surveys. LongPath has found linked leaks that it took more than one attempt to repair – without continuous monitoring, the first repair would not have mitigated all emissions, and the operator wouldn't have known that other problems persisted, despite OGI follow-up.

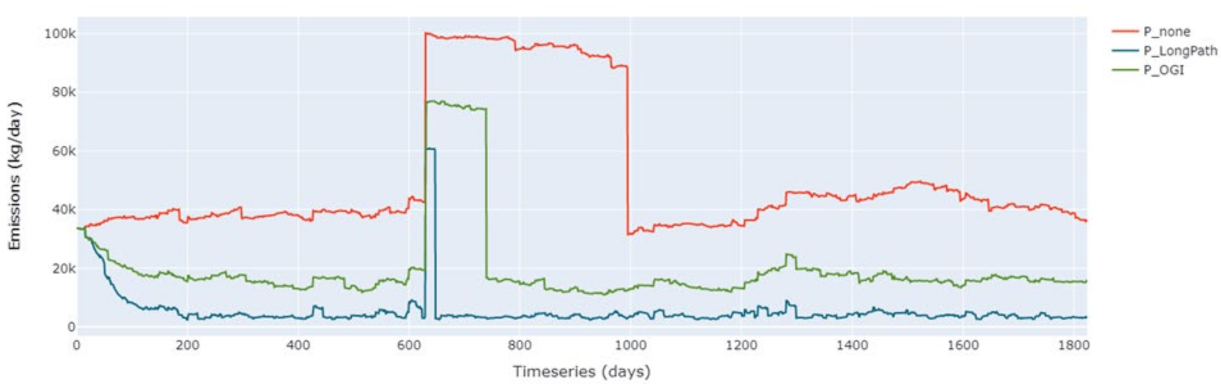
Continuous monitoring is highly scalable. With modest capital investment, around 1000 LongPath sensors could provide cost-effective continuous monitoring for most of the Permian Basin of West Texas and Southeastern New Mexico. Already, LongPath is continuously monitoring more than 230,000 acres in the DJ, Anadarko, Delaware and Midland basins. Once LongPath's networked infrastructure is in place, any site in the area can be quickly and cost-effectively subscribed. This includes orphaned and marginal wells, which LongPath can monitor, quantify and prioritize for plugging at a very low cost compared with other methods.

Finally, and most importantly, continuous monitoring affords rapid repair, such that cumulative emissions to the atmosphere are tens to hundreds of times lower than survey approaches can provide. The figure below is based on a real leak mitigated by LongPath; a stuck dump valve that was identified and repaired in 2 days, resulting in a cumulative loss to the atmosphere of 300 Mcf. A bi-monthly or quarterly survey might not have discovered the leak for 2-3 months, which would have resulted in some 30-50 times higher cumulative emissions emitted to the atmosphere. The difference in gas lost between continuous monitoring and a theoretical quarterly survey would have been 13,500 Mcf, or roughly 10.4 t. At a (currently below-market) value of $3.25 / Mcf, a loss of 13,800 Mcf is roughly $44,850 over 3 months. These losses dwarf the cost of the monitoring itself (and for many years) – a clear proof point that continuous monitoring is cost effective. The social cost of methane ($1,800/t) would equate to $18,720 saved compared with quarterly LDAR.

[13] Johnson and Heltzel, "On the Long-Term Temporal Variations in Methane Emissions from an Unconventional Natural Gas Well Site."
[14] Riddick et al., "Variability Observed over Time in Methane Emissions from Abandoned Oil and Gas Wells."



The below LDAR-Sim model results[15] show expected emissions given a LongPath emissions mitigation program ("P_LongPath", blue), a quarterly LDAR program ("P_OGI", green, with efficacy matching Zimmerle et al.[16]) and no LDAR program ("P_none", red). Interestingly, in this simulation, a super-emitter event occurs just following an OGI visit. While this would seem to be a rare event, LongPath has documented occurrences of this scenario in customer monitoring. In periods of both normal operations and during a fugitive event, LongPath's overall emissions reductions are substantially better than quarterly OGI.



EPA and continuous monitoring as an alternative means of compliance

LongPath has provided to EPA a detailed and complete work practice and framework for the inclusion of LongPath and other forms of continuous monitoring in the EPA's rule as an alternative means of compliance.

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[15] Highwood Emissions Management, January 2022.

[16] Zimmerle et al., "Detection Limits of Optical Gas Imaging for Natural Gas Leak Detection in Realistic Controlled Conditions."

Separately, we are providing to EPA, together with a diverse group of stakeholders, including industry, NGOs and legal experts, a matrix table for compliance under different frequencies and detection thresholds that is entirely technology-neutral, paving the way for regulations that will not hinder either current or future technological innovations.

Accompanying each method (technology) used to meet a given portion of the matrix table will be: 1) technology-specific work practices, 2) details of method certification, and 3) response requirements for when emissions exceed stated thresholds.

Elements of a framework provided to EPA by LongPath

LongPath provided a written response to all questions posed by EPA in the draft language published in November. These questions formed the EPA's pathway for inclusion of continuous monitoring as a compliance method in the final rule.

In addition to providing answers to the EPA's prompts, LongPath also outlined a specific framework for monitoring and response requirements that suit the LongPath technology class. No other technologies operate in the same way as LongPath, so we currently stand as the only C-Open Path (Continuous-Open Path) technology type in our class. Nonetheless, it is incumbent upon EPA to create rules open to all technology classes, regardless of how unique, and the offered matrix approach and generalized frameworks provide this ability.

Despite the work practice and response requirements being specific to the C-Open Path technology class, the bulk of the framework is generalizable to include all continuous monitoring platforms and the unique challenges posed by and solvable by continuous tech (e.g., the ability to characterize intermittent emissions and offer alternate response requirements than for persistent emissions).

Next Steps: R&D efforts needed to enable the EPA's proposed regulations

Formation of a neutral third party organization to: 1) set standards for testing of emissions detection work practices, 2) provide auditing of and testing of technologies with stated work practices, and 3) provide a clearing house for certification and reports.

The DOE and other federal institutions will be ideal venues for these efforts to be initiated and/or carried forward. Existing and new R&D dollars should be considered for use in the development of the standards, certification practices and clearinghouse for approved technologies.