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CERTIFIED DISASTER:

HOW PROJECT CANARY & GAS CERTIFICATION ARE MISLEADING MARKETS & GOVERNMENTS

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Cover Image: Earthworks 2022: Project Canary-S monitor placed below plume of pollution in Weld, County Colorado.

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Oil Change International is a research, communications, and advocacy organization focused on exposing the true costs of fossil fuels and facilitating the coming transition towards clean energy.

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If you have any questions or information you would like to share about Project Canary or Certified Gas, please contact priceofoil@proton.me

CONTENTS

EXECUTIVE SUMMARY

This report examines the gas certification market, specifically one of the current industry leaders, Project Canary. We raise serious concerns about the integrity of gas certification and so-called "Responsibly Sourced Gas" (RSG). Our investigation, which included field observations of oil and gas wells in Colorado monitored by Project Canary[a], exposed significant shortcomings in its operations and claims.

- **Project Canary monitors consistently fail to detect pollution events**: Earthworks' trained oil and gas thermographers captured alarming evidence of Project Canary monitors failing to detect emissions in the field. The seven-month survey found that Continuous Emissions Monitors (CEMs)[b] *failed to capture every significant pollution event* detected with Optical Gas Imaging (OGI) cameras. Our observations suggest that the company is misrepresenting the capabilities of its technology – a concern echoed in the testimony we gathered from several industry experts – and the underlying data behind certified gas.

- **Greenwashing**: Project Canary's marketing aggressively positions its certification services as a conduit to a 'net zero' emissions world. Its CEO has openly discussed fixing the gas industry's "brand problem." In doing so, the company appears to be aligning itself with gas industry lobbyists and pushing the concept of 'net zero' to new levels of incredulity, which risks sabotaging rather than serving global climate goals. The company is pushing a false narrative that methane gas is an energy source compatible with climate goals as long as it is certified as being produced below a certain methane threshold.

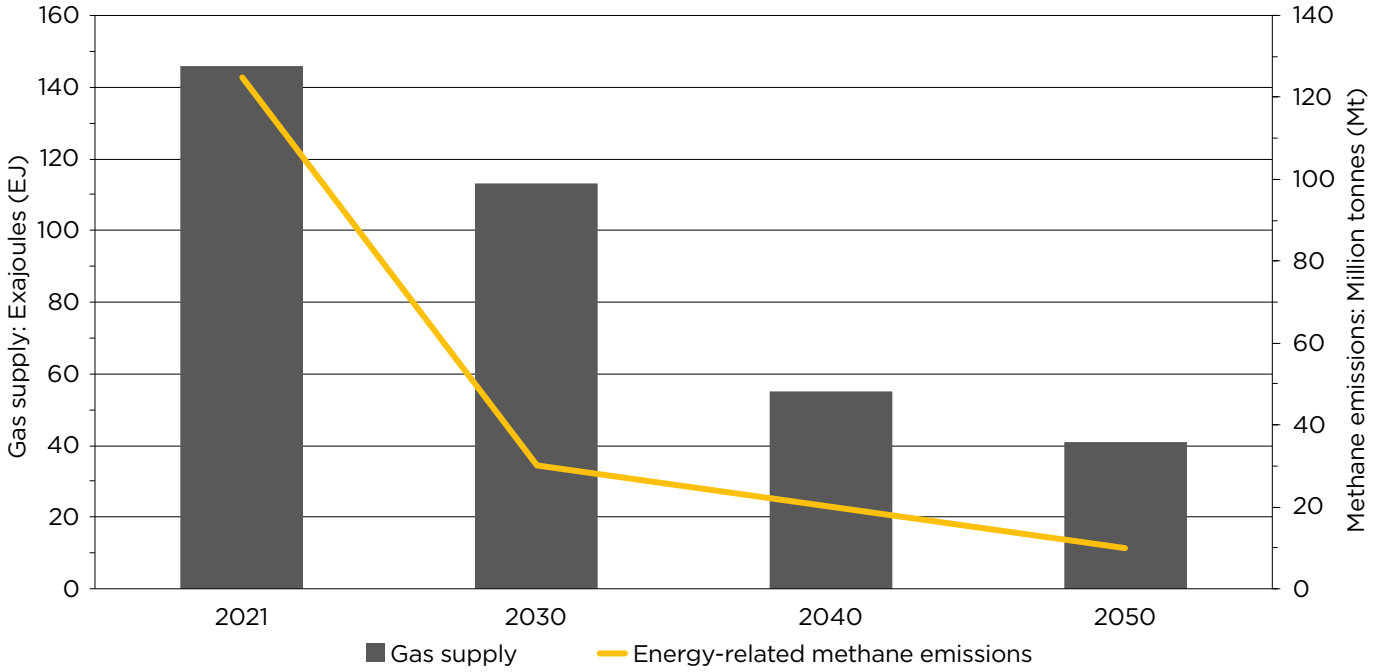
- **Lack of Transparency**: Despite claims of 'radical transparency' and third-party verification, there is limited access for regulators, academics, or the public to the data generated by the certification process. Given the evidence that monitoring may not be reliable, there is clear justification for greater scrutiny from regulators, scientists, and concerned citizens.

- **Conflicts of Interest**: Evidence suggests that a key Project Canary DIrector and Advisory Board Members have direct financial interests in the same gas companies it certifies.

Image by Earthworks, Weld County, CO - August, 2022

a Lack of transparency makes it impossible to know whether all Project Canary sites that are monitored are also producing "certified" gas.
b (14 Project Canary Canary-S, 5 SENSIT SPOD, 2 Aeroqual AQS-1 and 1 SGS SmartSense)

Figure ES.1: The Decline of Gas Supply and Methane Emissions in the IEA's 1.5°C Energy Scenario



Source: International Energy Agency (2022)[3]

Methane Reduction and the Phase-Out of Fossil Fuels

The International Energy Agency (IEA) estimates that the global oil and gas sector emitted over 82 million metric tons of methane in 2022.[1] Methane is a climate super-pollutant that traps over 80 times more heat in our atmosphere than carbon dioxide and is responsible for roughly 30% of the global warming we are experiencing today.[2]

Reducing methane emissions is absolutely critical to slowing the climate crisis, so it is imperative that any emissions reduction claims be not only independently verified but that regulators take action to prevent misleading claims. Assertions about the role of certified gas in preventing climate catastrophe also need to be grounded in climate science.

Notably, the most critical step to preventing the worst climate outcomes is phasing out fossil fuels entirely. Methane emissions reduction must happen in addition to the methane gas phase-out, not instead of it (see Figure ES.1). However, current certification schemes are being used to justify increased production and consumption of methane gas that will undermine emissions reductions.

Methane Mayhem: Regulatory Confusion

The gas certification sector has emerged in place of regulation following the Trump-era rollback of a methane rule initiated by the Obama administration. As such, it is defined by the same companies that seek to profit from it. There are currently no agreed-upon standards between different certifiers and operators. A recent report likened the current gas certification market to "a Wild West frontier filled with mudslinging and smoke and mirrors – and the gunslingers are deciding the rules as they go along."[4]

While the U.S. Environmental Protection Agency (EPA) is finalizing rules to limit methane pollution from the oil and gas sector, the gas certification industry has lobbied the Department of Energy (DOE) to define standards explicitly to ensure growth for U.S. Liquified Natural Gas (LNG) exports.[5] Project Canary lobbyists have pushed for the DOE endorsement and pressured the EPA to secure a role for its sensor technology in the Agency's final methane rule.[6]

While a robust methane rule, rigorously enforced, should effectively reduce emissions, it is clear that the industry has no intention of foregoing the opportunity to profit from "doing the right thing." There is money to be made in charging a premium for certified gas and assuring regulators and customers in climate–aware markets, such as Europe, that certified gas meets its criteria.

It is, therefore, imperative that regulators, customers, and investors, whether in the U.S. or abroad, demand the strictest possible procedures and standards and the greatest possible transparency. It is also crucial that regulators ensure the industry avoids making misleading claims about the impact and role of certified gas in the energy transition.

To this end, we make the following recommendations:

RECOMMENDATIONS

- **Accredited transition pathway:** Gas certification must include an independently accredited transition pathway away from gas to support the managed decline of fossil fuels required to address the climate crisis.

- **Transparency and public availability of monitoring data:** CEM monitoring is critical to addressing methane reduction, but the resulting data must be publicly available at a granular level. Monitors should also be subject to independent, peer-reviewed analysis to ensure they work effectively. A multi-faceted approach is necessary to ensure accountability at all levels.

- **Clear definitions and regulations for certified gas:** Certification is a separate issue from monitoring and, as a profit-driven marketing strategy, requires robust regulation with regard to domestic and global markets. Any gas deemed "certified," differentiated," or "responsibly sourced" must provide fully transparent and publicly accessible raw data to back up the claim.

- **Caution from buyers and investors:** Industry rhetoric and exaggerated claims make the methane gas market risky for consumers. Customers and investors can only be assured of the validity of certified gas if the full recommendations of this report are implemented.

Detailed recommendations for DOE/EPA/FTC and EU regulators can be found in the conclusions of this report on pages 33-34.

Image by Earthworks, Weld County, CO - August, 2021

An Important note on Community Monitoring Efforts.

It is important to note that this report is specifically focused on gas certification and monitoring technologies used in that application. Our research, analysis, and conclusions about monitors pertain specifically to industry efforts to use continuous emissions monitors as point source detectors and/or their use of certification schemes. This report is not a review of ambient air monitors used in community monitoring efforts. While monitoring technology used in both applications may be similar, what they are trying to achieve is very different. Community air monitoring with ambient air quality monitors is an important tool for people living next to dangerous sources of pollution.

1. INTRODUCTION

In late 2020, a decision by the French government rocked the U.S. methane gas industry. The French utility company Engie pulled out of negotiations over a 20-year, $7 billion contract for liquified natural gas (LNG) from the Rio Grande project in Brownsville, Texas, planned by NextDecade.[7] Engie had come under pressure from the French government, which controls 33% of the company, to drop the deal because the gas would come from the Permian Basin in Texas and New Mexico, which is associated with high emissions of the climate super-pollutant methane. At the time, studies suggested LNG from the Permian basin would be worse for the climate than coal.[8]

Fast forward two years, and Engie is back in the Rio Grande project along with several other clients.[9] The panic that surged through the industry following Engie's retreat in 2020 has morphed into a brazen new confidence that the U.S. gas industry has a positive story to tell.

America's oil and gas industry has moved on from denying its emissions problem to building a new narrative of a promising partnership between the gas industry and a small emerging group of technologically savvy young companies dedicated not only to cleaning up the industry but certifying its ostensible clean credentials. They come armed with new technologies to detect and measure methane and other pollutants. They offer certification programs that enable companies to present their operations as certifiably clean.[10, 11] This, in turn, allows companies to trade certified gas potentially at a premium. A whole new market is emerging, trading gas as "certified," "differentiated," or "responsibly sourced."[12, 13, 14]

Prominent among these companies is Denver-based Project Canary, which states on its website that it "accelerates progress to net zero with continuous monitoring and uncompromising certification technology."[15] Project Canary claims that its "certification is recognized as the most comprehensive certification in the market."[16] Major clients such as Southwestern Energy, one of the largest gas producers in the U.S., also maintain that Project Canary's certification process is the "most rigorous of anybody in the industry".[17] Project Canary argues, in turn, that they are bringing "radical transparency" to the gas industry.[18]

Verifying these claims is not easy. While companies are quick to issue press releases announcing the certification status of their operations and the low rates of methane venting associated with their gas production, publicly available data is lacking. While blockchain-enabled trading platforms are supposed to provide unprecedented transparency for traders by associating a secure dataset with transactions, public access is non-existent.

To verify the claims, Earthworks surveyors went to Colorado, where new well sites are mandated to install monitors and transmit the data back to the state regulator. They identified sites with Project Canary monitors and used thermographic cameras to detect emissions invisible to the naked eye. Where they found emissions, they checked official records, which are mandated by Colorado regulations, to see if the monitors detected and reported them. What they found was alarming and led them to investigate further.

In researching this report, we also spoke to numerous leading experts and industry insiders who expressed concerns about the integrity of gas certification generally and, in some cases, Project Canary specifically. They are concerned about the efficacy of equipment, data transparency, the lack of independent oversight, and the rush to certify while techniques and technologies are yet to be fully developed.

In monitoring Project Canary's public communications, particularly the public statements of CEO Chris Romer, we detected a clear strategy to portray leak detection and repair and gas certification as something it can never be: a "playbook"[19] that renders oil and gas production safe for the climate. Romer states that "we are going to be able to solve climate change with measurement."[20] He contends that Project Canary's "goal" is to allow the oil and gas industry to maintain "a social license to operate" and that "clean" certified carbon will allow the industry to operate "for many decades to come."[21]

We also found close ties between a key Project Canary Director and some Advisory Board Members and the company's customers. This raises questions about whether Project Canary might be compromised in certifying such a crucial element of a company's environmental performance, particularly when such certification can earn the company a premium for its product.

Before detailing the specific issues with Project Canary, this report provides some background on the oil and gas industry's methane emissions, the difficulty in reliably detecting and quantifying emissions, and the emergence of the gas certification industry. We then go on to provide a crash course on methane monitoring. Finally, we detail the findings of this investigation, including the field evidence from Project Canary monitored sites in Colorado, interviews with experts, and other analyses from our research.

Our findings raise serious concerns about the current status of U.S. gas certification and how it is being portrayed by proponents. We believe the evidence supports our call for pausing certification until the recommendations made in this report have been implemented.

2. THE GAS INDUSTRY'S METHANE PROBLEM

Methane is the primary constituent in what is known as natural gas. Methane is a hydrocarbon with the chemical signature CH_4, meaning it has four hydrogen atoms for every carbon atom. When combusted, it produces heat and carbon dioxide (CO_2) exactly as coal and oil do. The industry makes much of the fact that methane gas produces less CO_2 per unit of energy produced than coal and oil, even as burning methane gas emitted 7.3 billion metric tons of CO_2 in 2022.[22] However, measuring methane gas' climate impact only at the point of combustion ignores the significant amount of uncombusted methane emitted deliberately and accidentally throughout the oil and gas supply chain. Over 20 years, methane gas is more than 80 times more powerful than CO_2 and, as such, has been labeled a climate super-pollutant.[23]

Methane gas is routinely vented and leaked from the oil and gas supply chain, in addition to emitting significant amounts of carbon pollution when burned. It is this fact that undermines the industry's efforts to portray gas as a "clean" fossil fuel. It is vented as a routine procedure during drilling operations, the completion of wells, during maintenance of equipment and pipelines, and in various other everyday operations. It leaks from faulty equipment, from flares that are not operating properly or have gone out and not been relit, from abandoned oil and gas wells that have not been properly sealed, and from the distribution lines that bring gas into buildings. It is leaked and vented from LNG plants and the ships that transport LNG across the ocean. In the U.S. alone, there are likely millions of point sources of methane associated with the oil and gas sector.

The vast majority of oil and gas sector methane emissions are thought to come from the production, processing, and transportation stages.[24] The International Energy Agency (IEA) estimated that the global oil and gas sector released over 82 million metric tons of methane in 2022.[25] On a 20-year basis, this is equivalent to over 7 billion tons of CO_2, roughly the emissions of 1,900 coal power plants.[c,26] It is an absolutely vast pollution problem, endemic across the oil and gas sector and accelerating climate change at an alarming rate.

THE MEASUREMENT PROBLEM: NOBODY REALLY KNOWS

All estimates of methane emissions are exactly that, estimates. Until very recently, nobody was actively monitoring the methane emissions coming from oil and gas sites and equipment. In the U.S., the Environmental Protection Agency's (EPA) Greenhouse Gas Inventory (GHGI) provides estimates of methane emissions from the oil and gas sector using "bottom-up" inventories that multiply set emissions factors (for various types of equipment and activities) by total equipment or activity counts. For example, if a site uses ten valves of a certain type and those valves are documented as emitting, on average, 10 kilograms (kg) of methane per year, then the valves on that site are listed as emitting 100kg per year. The EPA inventory consists of thousands of such calculations to derive its total emissions estimate.

However, "top-down" studies – which rely on aircraft, satellite, or other field measurements – find much larger methane emissions from oil and gas activity. A 2021 study found that methane emissions in the U.S. oil and gas sector could be 1.5 to 2 times the EPA's GHGI, with "the production-segment as the dominant contributor to this divergence."[27]

The reason for this difference appears to be that the official EPA estimates rely on oversimplified and outdated emission factors which miss contributions from the very largest emission events, or "super-emitters." However, top-down studies are also estimates, generally taking snapshots of methane levels and modeling gathered data over wider periods. Therefore, neither bottom-up nor top-down methods systematically measure the emissions coming from oil and gas infrastructure.

The IEA's data is a combination of updated bottom-up estimates together with top-down estimates in an attempt to get a more comprehensive global estimate. But it is still an estimate. In releasing the 2022 IEA Methane Tracker, the IEA announced in a press release that methane emissions from the energy sector, which includes the coal and bioenergy subsectors, are 70% higher than official government estimates.[28]

Debate about the level of methane emissions associated with oil and gas production has been particularly active in the United States. Since 2005, U.S. oil and gas production has more than doubled. Hundreds of thousands of wells have been drilled, thousands of miles of new pipelines have been laid, and a new LNG export industry has been created. This has led to innumerable new methane point sources across the country.

c Based on average U.S. coal plant utilization.

The U.S. oil and gas boom was enabled by the emergence of hydraulic fracturing and horizontal drilling, also known as fracking. The frantic nature of the fracking boom, particularly in the Permian Basin in Texas and New Mexico, had until recently led to very low wholesale prices for methane gas as supply overwhelmed transport capacity and demand more generally.[29] While drillers in the Permian Basin, particularly, are focused on oil production, gas has often been treated as a waste product to be flared off when no market can be found or the price of processing and transporting it to market is higher than the price received.

The combination of little to no regulation, let alone enforcement, with the abundance of superfluous gas and low prices led to very high flaring and venting rates in the U.S. oil and gas industry. While official government (EPA) data underestimated this, the issue increasingly gained attention as multiple peer-reviewed studies indicated that emissions rates were higher than previously documented, and levels of methane detected in the atmosphere were rising.[30]

In March 2016, the U.S. and Canada announced a joint initiative to reduce methane emissions from the oil and gas sector.[31] The regulations were not implemented before the Trump administration granted the industry's wish to abandon them.[32]

Governments Take Action

As a growing number of studies reveal higher methane levels in U.S. oil and gas fields than government and industry figures had reported, gas has become increasingly problematic for regulators. In 2019, Berkeley, California, became the first U.S. city to ban methane gas in new buildings.[33] According to the Institute of Energy Research, a fossil fuel industry lobby group, 76 U.S. cities had enacted similar bans by August 2021,[34] mostly in California and the Northeast. Industry pushback was swift, and by mid-2022, 20 states had enacted legislation to outlaw gas bans.[35] But the blows to the industry kept coming, and this time from abroad.

The same week Engie pulled out of the LNG deal, the European Commission adopted a new methane strategy which included plans to develop "standards, targets or incentives for energy imports to the EU, and the tools for enforcing them."[36] The threat to LNG exporters targeting the European market was clear.

Despite its bravado in influencing pro-gas legislation in the U.S., the industry is increasingly aware that public opinion is turning against it. Acknowledgment of climate change in the U.S. and abroad is growing, and people blame fossil fuel companies.[37]

For standards to be set, for example, for LNG imports into the EU, companies would need to be able to verify how much methane has been emitted in the process of extracting, processing, transporting, and delivering the gas they export. For the U.S. oil and gas industry, the reckoning was coming. The future market may demand greater methane emission transparency.

The Biden Era

As the Biden administration took over the White House, the U.S. gas industry began to see the writing on the wall. Methane regulation was coming. Within the first few months of the administration, the newly appointed EPA administrator Michael Regan told Reuters that "(w)e're laser-focused on methane and how we limit methane emissions from natural gas operations nationwide."[38] Meanwhile, in Congress, legislators took action to reinstate Obama-era oil and gas methane rules, which had been rolled back by the previous Trump administration.[39]

In September 2021, the Biden administration, together with the EU, announced that the Global Methane Pledge would be launched at the COP26 conference in Glasgow. Countries joining the pledge would "commit to a collective goal of reducing global methane emissions by at least 30 percent from 2020 levels by 2030 and mov(e) towards using best available inventory methodologies to quantify methane emissions, with a particular focus on high emission sources."[40]

The EPA is currently finalizing rules to limit methane and volatile organic compound (VOC) pollution from new and existing oil and gas infrastructure. These rules will expand on Obama-era new source standards to cover all existing sources of methane and VOC emissions from the oil and gas sector.[41] After lobbying from Project Canary and other emissions technology providers,[42] the EPA has updated its draft rule with a sizable section outlining how companies could apply to use "Alternative Continuous Monitoring Systems" – such as those offered by Project Canary – in a specified and approved "Alternative Test Method" in place of OGI leak detection.[43]

Meanwhile, provisions in the Inflation Reduction Act, enacted in August 2022, impose a penalty on methane emissions starting in 2025. While the precise details of how methane emissions will be regulated in the U.S. – including how they will be monitored and measured – are yet to be determined, it seems clear that change is coming. Even if U.S. regulations are weakened, the prospect of LNG-importing countries imposing tough standards on imports remains.

The mounting pressure for regulation, the prospect of climate-conscious governments mandating rapid transitions away from gas, and the development of technology for detecting and monitoring emissions, have led some companies to embrace a new idea that Project Canary and a handful of other companies are selling. That idea is gas certification.

3. WHAT IS GAS CERTIFICATION?

Third-party monitoring of the industry and gas certification was likely first conceived in 2013 when the ex-banker Jory Caulkins founded Independent Energy Standards (IES). Caulkins, who had worked at Bain Capital and Morgan Stanley, told Natural Gas Intelligence that he had "little experience" in the energy industry but was always looking for the next promising business opportunity.[44, 45] IES launched the TrustWell verification scheme, which monitors and analyzes a wide range of a gas production site's environmental impacts, including methane emissions, air and water quality, and safety.[46]

Project Canary merged with IES in 2020 and uses the Trustwell system and brand as a central part of its gas certification scheme. By June 2019, it used the term: "Trustwell: Responsible Gas" in presentations[47], with "responsibly sourced gas" trademarked by Project Canary in September of that year. Project Canary has since relinquished the trademark,[48] so that, in the company's words, "it can become the new standard throughout the U.S. and, hopefully soon, the world."[49]

The first recorded sale of certified gas by IES took place in September 2018 when Southwestern Energy sold an undisclosed amount to New Jersey Natural Gas.[50] By November 2022, Platts reported that some 26 billion cubic feet per day of U.S. gas production (roughly 25 percent) were "certified."[51] In January 2023, Project Canary told E&E News that the figure was closer to 30 percent.[52] Others have speculated that around 50 percent might be certified in the next few years[53] reaching 100% by 2030.[54]

Certified gas involves a process where the certifying entity monitors a gas production or processing site – a gas well, a processing plant, or a pipeline compressor station – and measures the emissions over time to determine the level of emissions associated with the gas produced. The certifier works with the operator to identify emissions sources and reduce or eliminate them. Once emissions are below a certain threshold, the gas produced or handled at that site is certified. The operator can then trade an equivalent amount of gas using the certificate to validate claims made about the emissions associated with it.

According to Platts, Project Canary is one of two main "standard setters" in the U.S. gas certification space.[55] The other is a not-for-profit certifier called MiQ. Platts states that a third, Equitable Origin, is usually used in tandem with MiQ.[56]

There is currently no regulation of gas certification. It is, therefore, not surprising that each company uses different criteria, technology, and methodology to certify a client's gas. Project Canary, for example, operates a twin-track approach. Primarily, it uses a network of Continuous Emissions Monitoring (CEM) – at the site level. The monitoring data is uploaded to Canary's central dashboard every minute, enabling Canary's clients to access the data in real time via the cloud. Project Canary claims this real-time monitoring delivers "measured and quantified methane emissions and total site emissions"[57] so that "our customers can catch even intermittent leaks and get credit for environmental performance."[58] Once production sites have operated for a designated time period with emissions kept below a certain level, the gas from those sites is certified. Monitoring continues at the sites, and the certification status is reviewed annually.

In addition, Project Canary uses the TrustWell system it acquired from IES.[59] Sites assessed using TrustWell are certified along a spectrum running from Platinum, through Gold and Silver, with Platinum scoring the highest, meaning an operator is deemed to be "more responsible than 90% of other operators".[60] A site that achieves Platinum or Gold status can be marketed as "responsibly sourced gas."

MiQ takes a different approach involving field inspections and assessments of policies and procedures.[61] MiQ's chief executive, Georges Tijbosch, has criticized Project Canary's CEM methodology as relying too heavily on technology that "doesn't always work right" in the field.[62]

The fact that the two main certifiers currently operating in the U.S. use entirely different approaches points to the need for regulatory intervention. In a recent investigation into the emerging "green-gas market," one author described the current situation as "a Wild West frontier filled with mudslinging and smoke and mirrors – and the gunslingers are deciding the rules as they go along."[63]

Others have pointed out how easy the market is to manipulate. For example, Project Canary's clients choose which part of their operations are inspected, potentially avoiding sites they know to have issues.[64] In an interview with Canary Media[d] on gas certification, Chris Romer said, "This is a legitimate criticism of Project Canary: Can companies just cherry-pick their best pads?" Although Romer added that he did not think his clients would "avoid the moral hazard of cherry-picking," he did not "have the ability to mandate that people do 100 percent" of the gas in their system.

d Canary Media is unrelated to Project Canary

Image by Earthworks, Weld County, CO - August, 2022

Some companies are also "shopping the market," getting Project Canary to certify one part of their operations and its competitor another.[65] There is precious little detail available on what the parameters are for certified gas across companies, production basins, or the supply chain.

One former industry insider told us that "There are two different ways to think of methane certification. One way is a bridge to reducing emissions. The other side is a way to preserve extraction and differentiate in the market with ESG." The former paints the U.S. gas industry as belatedly moving toward aligning itself with universally agreed climate goals. The latter is essentially a greenwashing tool to allow continued extraction. That is why "some companies are going headfirst for methane certification. Others completely hate it," said the former insider.[66]

TRADING CERTIFIED GAS

In the absence of methane regulation, gas certification has emerged as an industry-led initiative to address an issue that incurs reputational damage and threatens growth. That damage is made tangible by the city bans on new gas hook-ups and the Engie withdrawal from the Rio Grande LNG project. In other words, it costs money. But the calculus behind paying a third party to certify emissions and environmental performance is not solely based on stemming a market loss. It is also based on the potential to charge a premium for ostensibly cleaner gas. There is money to be made.

Selling "responsibly sourced gas" at a premium has always been a primary driver for the fledgling industry. When Jory Caulkins was at the helm of IES, his sales pitch included a "value proposition" for the oil and gas sector, where it could "reward continuous improvement."[67]

Caulkins asserted that end-use consumers would be willing to pay a 20% premium for certified gas.[68] Romer has followed in the same vein. He believes "going green" is a "profit strategy," whereby certification costs a supplier a quarter to a half-cent per thousand cubic feet (mcf), but "people are now able to sell premium gas at 3-5 cents" mcf. Romer says, "The good news is the rates of return for all of us who are on the right side of this new regenerative relationship with carbon are going to be phenomenal."[69] Romer's sentiments are being borne out: One industry website reported last year that "recent deals for certified gas have secured a premium of 3-7 cents/MMBtu, about 1-2% over commoditized gas prices."[70]

But while there is money to be made selling certified gas at a premium, companies can also exploit it via emissions trading platforms. Certified gas is generally traded via bilateral contracts between suppliers and customers such as traders or utilities, for example, the inaugural certified gas deal between Southwestern and New Jersey Gas. However, Project Canary and its customers are monetizing other revenue streams for certified gas.

In December 2021, Project Canary announced it was joining the Digital Fuels Program of Xpansiv, the leading "global marketplace for ESG-inclusive commodities." According to Xpansiv, the Program "establishes a new class of tradeable, standardized environmental assets" that can be recorded and traded by using a digital twin comparable to specific units of energy produced or transported.[71]

The system, which Xpansiv argues is akin to renewable energy credits, includes a "data-driven registry and exchange" for issuing, transacting, and retiring the environmental performance attributes of different fuels. These include natural gas, crude oil, hydrogen, and aviation fuel.

Not only would Project Canary deliver methane-emissions data to the registry but

Image by Earthworks, Weld County, CO - August, 2022

its TrustWell certification standard could be registered on Xpansiv's DF Registry too, where both could be "transacted and retired."[72, 73]

In December 2022, Project Canary announced that it was expanding its partnership with Xpansiv, "to publish verifiable climate attributes" which would "allow buyers to meet net-zero goals with verifiable environmental claims." Data from Project Canary's TrustWell scheme and methane monitoring would be stored on the Xpansiv Registry.[74]

Project Canary is also working with partners on developing blockchain-enabled tokens. Blockchains are increasingly being used by companies trading emissions because data records on a blockchain are immutable, they cannot be changed, and can help facilitate peer-to-peer transactions, especially in the context of weak regulatory oversight.[75]

In September 2022, Project Canary announced it was teaming up with EarnDLT to form a blockchain-based Emissions Accounting System, which aims "to facilitate the growth" of the RSG market by "increasing stakeholders' confidence around tracking, transferring, and retiring environmental attributes."[76] EarnDLT adds that this offers an easier solution for "monetizing the low-emissions data associated with their RSG molecules."[77]

In November 2022, the partnership announced that "verifiable low-methane emissions data attributes associated with PureWest's gas production," as well as "other environmental attributes" certified by Project Canary, will be transformed "into digital tokens stored on the blockchain" becoming "available for purchase by end users or third parties looking to achieve their net zero emission goals."[78] The attributes not only include methane intensity but other environmental indicators such as water use.[79]

There is an ongoing debate about the efficacy of emissions trading in sufficiently reducing climate emissions.[80] But what is clear is that the data going into any emissions trading platform must be reliable. The evidence presented in this report suggests that that is far from the case today. Without implementing this report's recommendations, the trade in the environmental attributes of certified gas may undermine the rationale for emissions trading, which is reducing emissions.

ENABLING OTHER FALSE CLIMATE SOLUTIONS

Project Canary has announced its intention to expand its certification service to other oil and gas industry emissions reduction efforts. These include Carbon Capture and Storage (CCS) and the manufacture of so-called Blue Hydrogen, which is hydrogen manufactured from methane gas combined with the capture of CO_2 from the methane-to-hydrogen conversion process. Both of these things have been labeled "false solutions" by environmental groups.[81]

In January 2023, Project Canary announced it was developing a new third-party verification framework for CCS. CCS aims to capture CO_2 emissions from power plants or industrial processes and sequester them underground. In many cases, the CO_2 is used to repressurize old oil and gas wells to increase production, rendering the net emissions reductions minimal at best.[82]

CEO Chris Romer says Project Canary can help companies "transparently demonstrate safe, permanent carbon storage in specific, evaluated, and approved geologic formations." This would "help secure your social license to operate." Project Canary's website states that it "look(s) forward to partnering with market leaders to become the trusted provider of third-party verified climate attributes for the CCS space."[83] Project Canary's role in facilitating the carbon capture industry will likely expose it to further scrutiny from climate advocates.

4. WHAT IS PROJECT CANARY?

Project Canary is a Colorado-based Public Benefit Corporation that was initially incorporated in August 2018.[84] It gained its Public Benefit status in September 2019,[85, 86] which at one time was listed at the head of the company timeline.[87] However, through acquiring several companies, the personnel and technologies that form the company today have origins that go back to at least 2013.

Project Canary describes itself as a software-as-a-service (SaaS) company that "collects, analyzes, quantifies, and visualizes asset-level environmental risk assessments and emission profiles."[88] It claims to be "the data-driven foundation of the energy ESG marketplace" and to "accelerate progress to net-zero with continuous monitoring and uncompromising certification technology."[89]

The company's current CEO is Chris Romer, an ex-Colorado Senator who describes himself as a pro-fracking Democrat – "Like Joe Manchin, I have been a Democrat for natural gas for many years." Romer says the reason for Project Canary was that "we had this hypothesis that responsibly sourced gas at the pad level would prove that a lot of unconventional gas – sometimes called fracked gas in the U.S. – is actually very clean and was worthy of the climate solution." Romer argues that "people need to understand that this is the cleanest carbon on the planet, and we need to bring two billion people out of poverty with this enormously clean carbon fuel." He adds, "We need to expand LNG globally by a big number. The U.S. is ready to do that in a very big way. We would love it to be certified gas. We would love it to be Project Canary-certified gas."[90]

To this end, Project Canary is positioning itself as a leading player in what Romer describes as "the measurement economy."[91] Speaking in a video on its website, CEO Chris Romer says: "What Project Canary is about is making sure that we stop the way we are putting carbon dioxide and methane into the air that is harming the atmosphere and heating up the planet." Romer adds that they provide "trusted independent data on environment, social and governance, so you as a corporation or you as a consumer know which products to buy. You will know who is on the right side of history."[92]

In addition to methane monitoring, Project Canary also provides services that measure volatile organic compounds (VOCs), ethane, benzene, water use, and other environmental indicators. "The industry's holy grail has become to have rugged, affordable and reliable continuous monitoring," argues Romer, "We really are the first to accomplish that."

Project Canary has grown quickly since its inception in 2018 and taking over of IES. In December 2020, Project Canary acquired its first major company, called Troposphere Monitoring, a "leader in hydrocarbon emissions sensor technology." Several scientists from Troposhere joined Project Canary, including Dr. Anna Scott, who became the company's new president, although she has since relinquished that position.[93]

The company's second major acquisition came in March 2022 with the takeover of Aeris Technologies, a "leading provider of laser-based gas analyzers and leak detection systems." At the time, Chris Romer said that Aeris Technologies "are the right partner at the right time to fast-track our growth and help deliver our generation's most critical ESG climate solutions for multiple industries."[94] In February 2022, it closed on a $111 million Series B financing round[95] enabling it to expand its operation significantly and acquire Aeries Technologies the following month.[96]

As of early 2023, Project Canary's website disclosed it was undertaking over 760 million monthly measurements from over 1,700 methane monitors.[97] The company certifies over 10 billion cubic feet of gas per day in three different countries, including its first project outside the U.S., Kellas Midstream in the United Kingdom.[98, 99] Apart from Kellas, the majority of Project Canary's customers are in the U.S., including some of America's biggest gas producers, as well as pipeline operators, LNG suppliers, and utilities. Most of these are producers. As of January 2023, the company was working with over sixty customers.[100] A table of the company's main customers is in Appendix A.

5. GROUND TRUTHING PROJECT CANARY'S METHANE MONITORING

Certification of the U.S. gas supply is moving quickly. But industry experts have expressed concerns that the technologies and methods used are still in relatively early stages of development. In many cases, limited peer-reviewed literature is available for assessing their efficacy. It is critical to understand the limitations of methane monitoring technology to understand whether gas certification is delivering on its promise today and whether it ever will.

In this section, we first describe the technology and methods commonly used by gas certifiers. We also describe the technology used by the Earthworks research team. We then present evidence from seven months of field observations of Project Canary-monitored sites in Colorado by the Earthworks research team. Finally, we present excerpts from interviews with industry experts describing their concerns with the current status of methane monitoring technology.

CRASH COURSE ON METHANE MONITORING

As we have discussed, methane emissions from the U.S. oil and gas sector are underreported and largely unmeasured. As global attention to the super-pollutant power of methane continues to grow, so does the demand to monitor, measure, and mitigate its release into the atmosphere. A burgeoning market of technological devices promises to "measure what matters,"[101] from methane-sensing satellites orbiting the Earth to handheld methane sensors in the field. Many of these are sold alongside services that include everything from algorithmic analytics[102] to certification of assets, operations, or entire companies, such as Project Canary's TrustWell certification.[103] This emerging "field of methane measurement is young, with myriad players experimenting with myriad techniques."[104]

Methane emissions resulting from oil and gas industry activities can be monitored and measured in various ways – it is important to distinguish the different aspects of these processes.[105]

Technologies refer to the different types of gas sensing instruments, primarily distinguished by cost, accuracy, and ease of use, as well as temporal and spatial capacity (e.g., how often they collect readings and how many pieces of equipment they can monitor at once).

Methods combine using a specific type of technology, a detailed accounting of how that technology will be effectively deployed, and a discussion of how analytics will be used to inform LDAR (Leak Detection and Repair) decisions.

An LDAR program describes systematically implementing one or more technologies and methods across a collection of assets, repair response plans, and reporting standards. "Ultimately, it is the LDAR program that results in emissions mitigation, not the technologies or methods in isolation."[106]

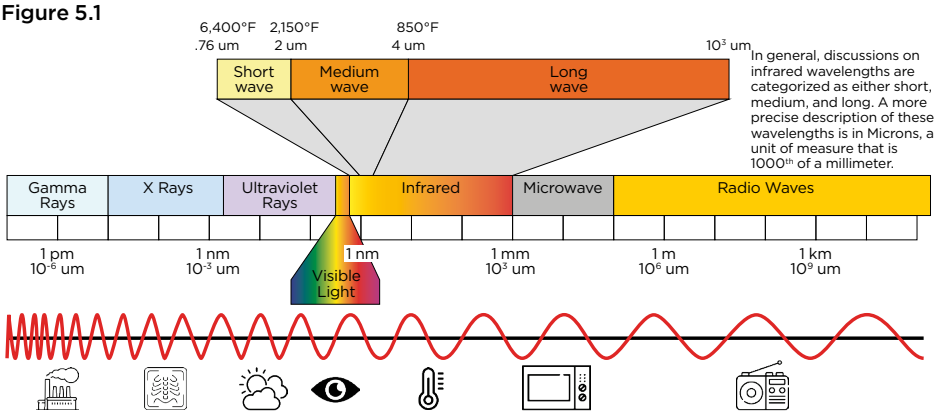
These distinctions are important because accurate and appropriate technologies must be paired with reliable and valid methods in a thoughtful, systematic, and comprehensive way to implement an effective emissions reduction program.

In this report, we compared the monitoring results of two different types of methane monitors – the oil and gas industry sites surveyed in this report employed "continuous emissions monitors" (CEMs), while Earthworks employed a FLIR optical gas imaging (OGI) camera. These monitors are not directly comparable. Therefore, it is important to understand each monitor, its limitations, and peer-reviewed evidence of its efficacy.

Optical Gas Imaging (OGI)

OGI cameras are powerful, handheld, scientific instruments that use infrared thermal-imaging processes and spectral filters to visualize the presence of various hydrocarbon and VOC emissions based on their unique electromagnetic radiation absorption patterns (or wavelengths). This technology can detect the short, medium, or long wavelengths within the "infrared" portion of the spectrum. Our investigators used the FLIR GF320 OGI camera with a spectral range of 3.2 – 3.4 Qm (or medium wave),[107] well-suited for the detection of most hydrocarbons.[108]

Figure 5.1



Source: "Infrared Basics: The Electromagnetic Spectrum," OpenEI, 2013.[e]

e See also "Infrared Basics: The Electromagnetic Spectrum," Protherm, 2011. [link]

Essentially, OGI cameras take pollution that is invisible to the naked eye and make it visible, recordable, and in some cases, measurable, all in real-time.

OGI cameras were first used in 2005.[109] They quickly surpassed the more simplistic toxic vapor analyzers (aka "gas sniffers") as they were more efficient, more sensitive, generated more easily communicable and intuitive results, and allowed for better operator safety. In 2008, the EPA declared OGI cameras could be used instead of "gas sniffers" in programs LDAR.[110] By 2016, the EPA had conducted several studies and concluded that OGI was the "best system of emission reduction" for both oil and gas well sites and compressor stations.[111] Additionally, numerous peer-reviewed studies have demonstrated the efficacy of OGI cameras for detecting emissions associated with oil and gas industry activities.[112, 113, 114, 115, 116]

Some limitations are associated with using OGI for emissions/pollution detection. In the hands of appropriately trained operators, OGI is great at detecting the presence of emissions and locating their source but not effective at quantifying emissions. High wind speeds, low ambient air temperatures, and low background contrast pose challenges for OGI.[117] Quantification capacity is a relatively new improvement and has yet to be adequately verified via independent or peer-reviewed analysis.

Continuous Emissions Monitors (CEMs)

Companies selling CEMs often promise real-time, 24/7 monitoring; automatic upload of data to a cloud service; AI or machine-learning informed analysis; point-source detection and; third-party, independent verification. However, there is scant publicly available information about monitors and analytic processes. Furthermore, there is little consensus in the tech industry, oil and gas industry, research literature, and regulatory schemes regarding what to call these monitors and associated services.

Project Canary currently offers several different monitor options.[118] While it is exceedingly difficult to find publicly available information about the specific types of sensors used in Project Canary's monitor setups, what information exists suggests that Canary-S monitors rely on relatively simple photoionization detectors, a type of monitor that is part of the larger class of CEM technologies.[119, 120, 121]

Oil Change International. A pumpjack in the Permian Basin in New Mexico in 2019.

Photoionization Detectors (PIDs)

PIDs[122] typically consist of at least five major components: a power source, an ultraviolet lamp, an ionization chamber, electrodes, and a display or some other means of reporting data collected (e.g., upload to a cloud service). They are often small enough to be handheld and can be configured in various ways (e.g., different power sources, lamp strengths, etc.) to best detect a specific gas. The ultraviolet lamp emits photons that are absorbed by a gas inside an ionization chamber; the electrodes then collect the ions produced in the process. The current produced in this process allows for measuring the gas in question.

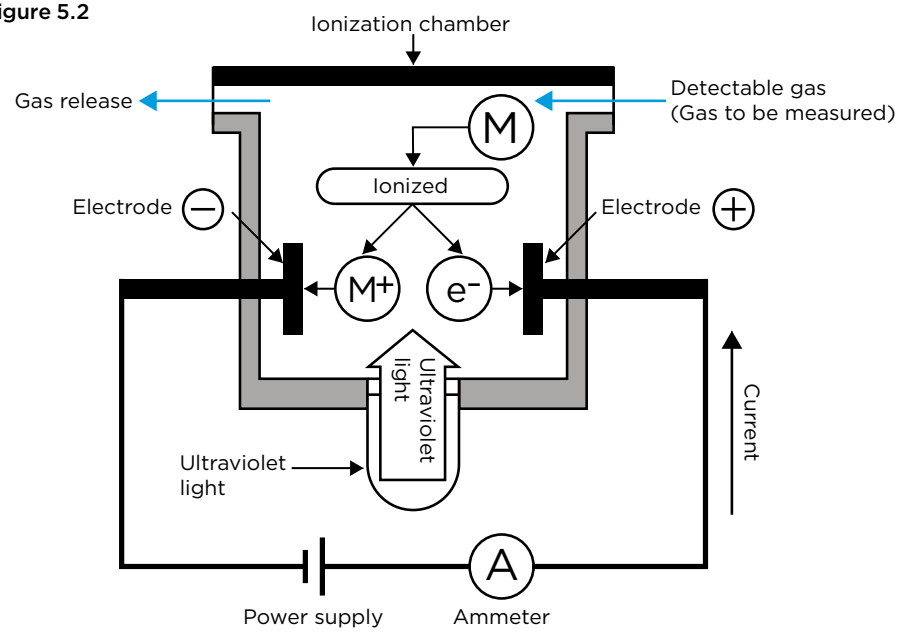
Essentially, PIDs are a piece of hardware designed to record ambient gas concentrations (detection levels vary) in a specific place at certain intervals (every second, minute, hour, etc.). Then, the software kicks in, and an algorithm translates each moment of data collected into a log of emission events. These algorithms vary in complexity and efficacy, they can be built to take into account several different considerations, such as wind speed, wind direction, temperature, humidity, or background levels of a gas; they can use a variety of different dispersion models to estimate the size and location of the emission; and, they can be set to create an alarm if a pre-set threshold is exceeded.

However, PIDs have several significant limitations.

- They are "not suitable for the detection of semi-volatile organic compounds;"
- They can indicate the presence of VOCs, "but do not identify the type (unless combined with a gas chromatograph);"
- They "may give false positive readings for water vapor, rain may affect performance, [and] high humidity can cause lamp fogging and decreased sensitivity."[123]

Furthermore, the performance of PIDs can also be hindered in contexts of high methane concentrations, rapid temperature variation, strong electrical fields, or by the presence of other naturally occurring compounds (such as high levels of terpenes in wooded areas). They also require frequent re-calibration.[124]

Figure 5.2



Source: Oil Change International & Earthworks, based on "What is Photoionization Detector (PID)?" Instrumentation tools, 2023

Limitations of CEMs for Oil and Gas Emissions Monitoring

A recent Methane Emissions Technology Evaluation Center (METEC) test[125] of 11 different sensor systems, including Project Canary monitors, found wide variability in true/false positive rates and a tradeoff in terms of detection sensitivity and false positive rates. Only four sensors had true positive rates exceeding 50%, but two of these four also had false positive rates exceeding 50%, which means that someone flipping a coin could have been as accurate as either of these two systems. Six sensors had false positive rates below 10%, but they also had lower true positive rates – three had true positive rates below 10%, and the other three ranged from 24-59%.

There was also wide variability in location attribution capabilities. None of the sensor systems tested were accurate to within +/- 40% when emissions were <1 kg/h (whereas such emissions would be routinely identified and fixed using OGI). These issues led the authors to conclude that continuous monitors should be used with caution as "detection limits, probability of detection, localization, and quantification may or may not be fit-for-purpose for any given application" and "relying on quantification estimates from these solutions for emissions reporting is likely premature at this point."[126]

Likewise, other researchers examining the utility of CEMs also found that at this time, accurate site-level or equipment-specific emission quantification "is still an open problem."[127] CEMs do not have reliable localization capabilities, and "it is unclear whether that can be accomplished using low-cost sensors."[114] Furthermore, there is wide variability in emission detection capacity relative to the size of emissions, a host of issues with various methods of plume analysis, and "instabilities in sensors [can] reduce periods when reliable information can be collected."[128]

Additionally, other studies bring attention to the effects topography, micrometeorological conditions, basin-specific characteristics, and human error can have on results since CEMs need to be appropriately placed on-site so that any emission plume has a "high probability of intersecting one or more sensors, regardless of wind direction."[129] Determining the appropriate placement is challenging, as emissions associated with oil and gas industry activities exhibit high spatial and temporal variability. Yet, CEMs are fixed in one location, and changes in wind speed and direction have a significant effect on detection capabilities.[114] Sensor placement and algorithm development need to be able to account for the complexity of the environment into which they are deployed, including the type of equipment being monitored; the number of pieces of equipment; the distance between monitors and equipment monitored; potential

sources of interference; the effects of humidity, water vapor, and wind; and, the effects of stagnation and dilution.[115] Lastly, methane emissions vary considerably within and across oil and gas basins,[130] and can evolve over time as infrastructure ages, new wells are drilled, or production declines,[131] therefore "measurement approaches should be based on basin-specific characteristics."[113]

Notably, continuous monitor testing and research often happen in a controlled environment, where only one emission point is active at a given time, and the location/size of that emission is known. Such tests or studies present the upper bounds of accuracy and reliability and rarely accurately reflect real-world applications.

Regardless of the type of technology used (except for OGI), "most sensors and platforms have not been sufficiently evaluated under a range of environmental and operational conditions."[132] Furthermore, existing "published measurement ranges may not be representative, and context-dependent detection probability distributions should be developed before different technologies can be reliably compared."[102]

These limitations illuminate the "methodological minefield that is the effort to calculate oil-and-gas methane leaks."[94]

The Director of METEC, Dan Zimmerle, cuts through all the techno-hype surrounding innovative methods of emissions detection with a hard truth: "I often say that leak detection is the worst of about five ways of reducing methane emissions. It's roughly equivalent to detecting overloads on your household circuits with smoke alarms. It comes a little late in the process."[133]

With this in mind, Earthworks set out to gather data to test the effectiveness of Project Canary's monitors as implemented on a variety of oil and gas production sites.

EARTHWORKS FIELD EVIDENCE

In 2021, the Colorado Department of Public Health and Environment (CDPHE) adopted new permitting requirements for all new oil and gas wells under Regulation 7 Part D VI.C (referred to as "Regulation 7"), which states: "Owners or operators of drilling operations that begin on or after May 1, 2021, must monitor air quality at and/or around the pre-production and early production operations."[134] The regulation requires that operators use continuous emissions monitors (CEMs), like Project Canary's Canary-S monitor, to either monitor methane directly or through known precursors like Volatile Organic Compounds (VOCs) such as Benzyne, Toluene, Ethylbenzene, and Xylene (BTEX).

It also requires operators to create an Air Quality Monitoring Plan (AQMP) to provide technical details about what monitors will be used, how they will be deployed, what pollution they will detect, and what thresholds define an event that requires operator response. Additionally, operators must submit monthly reports, including hourly monitoring data (averages of 60 one-minute readings), equipment failures, and the total number of pollution events requiring action for that month.

Such regulations create a baseline standard of reporting that can then be tested and verified using other technologies to ensure that companies are living up to the ideals they are promoting. Documents associated with regulations at the local, state, and federal levels are often publicly available upon request. This includes permit applications, monitoring reports, and notices of violations, to name just a few.

While studies show CEMs can be reliable in controlled test settings,[135] these tests represent a significant simplification of field conditions.[136] Comparing Earthworks field observations with data reported to the CDPHE under Regulation 7 provides an opportunity to gain insight into the practical capabilities of CEMs.

Methodology

Earthworks uses industry-standard FLIR GF320 Optical Gas Imaging (OGI) cameras designed to detect and visualize 20 volatile organic compounds that cannot be detected by the naked eye, including the carcinogens benzene and toluene as well as methane. Earthworks camera operators are ITC (Infrared Training Center) certified optical gas imaging thermographers. The cameras are routinely calibrated by FLIR in accordance with their standards for accurate recording.

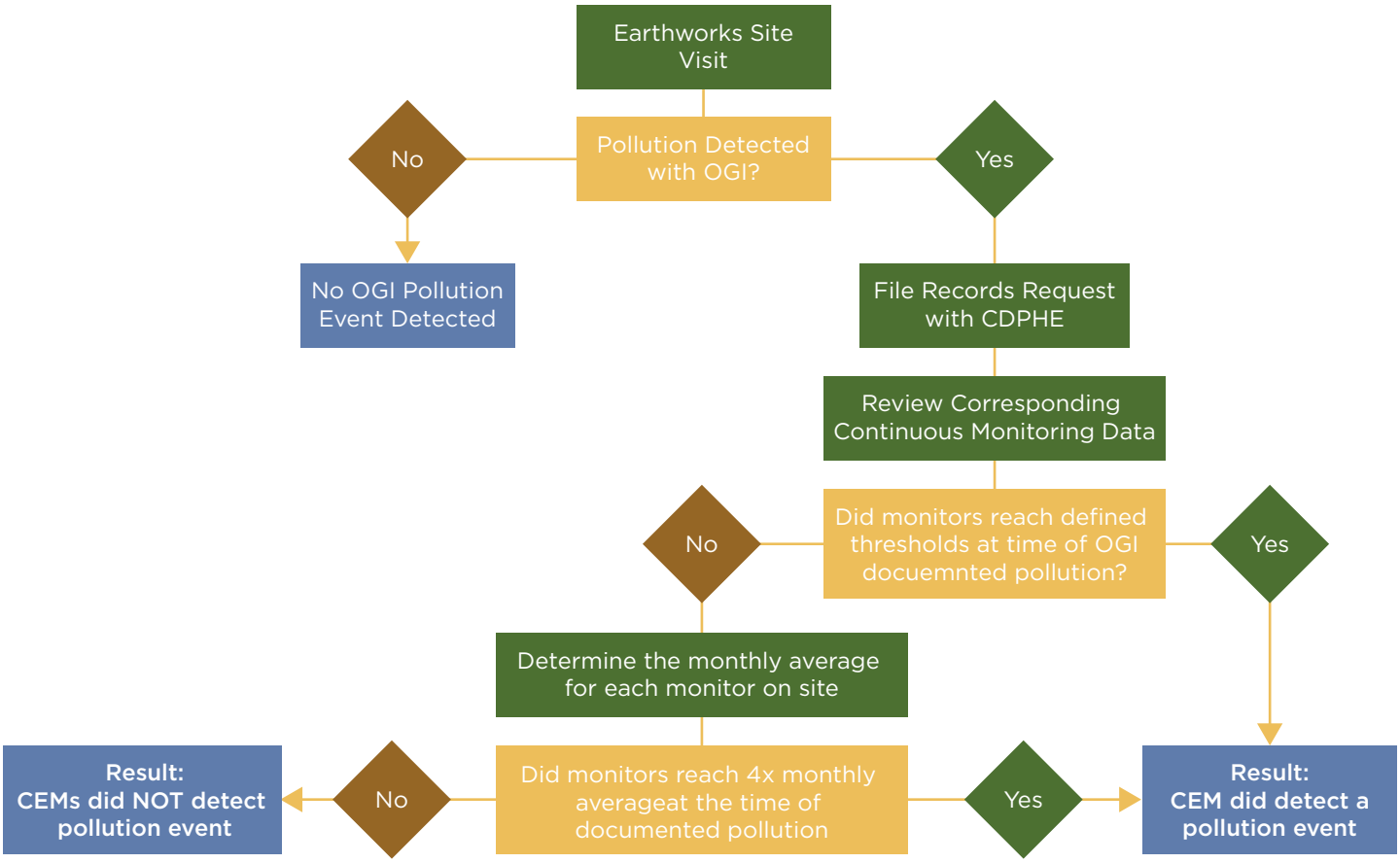
Over a period of seven months in 2022 (May-November), Earthworks' certified thermographers conducted a total of 77 surveys of 30 different oil and gas production sites in the Front Range where Photoionization Detector (PID) based CEMs were deployed. These sites were selected because they had recently been permitted and therefore were part of the CDPHE Regulation 7 program. Because Earthworks field advocates spend the majority of their time helping communities document issues from oil and gas sites across the state, we limited our visits to sites based on factors such as convenience of access, proximity to others we had already planned to visit for community complaints, and certainty that the wells had valid monitoring plans and monitor types were known. These same factors also played into whether or not we returned to a site again.

The breakdown of monitors is as follows: 21 of these sites used Project Canary Canary-S monitors, six used SENSIT SPOD monitors, two used Aeroqual AQS-1 monitors, and one used SGS Smart Sense monitors.

Earthworks recorded 22 pollution events (14 at sites with Project Canary-S monitors, five at sites with SENSE-IT SPOD monitors, two at sites with Aeroqual AQS-1 monitors, and one at a site with SGS SmartSense monitors) from a wide variety of well site activities spanning production phases – including emissions from drilling, fracking, flaring, venting, and maintenance. The team then verified that footage with independent industry professionals and, when necessary, submitted that footage as an official complaint to the CDPHE.

In response to these observations, CDPHE shared Earthworks' footage with operators and requested that they investigate and identify any air quality compliance issues. In all cases, operators claimed they could not identify any issues or noncompliance and, in some instances, cited their CEM readings to reinforce these claims. When operators provided CDPHE with CEM readings as evidence, Earthworks documented how those data sets further confirmed CEM failures.

Figure 5.3 Visualization of Earthworks' Case Study Process



Source: Earthworks

Limitations

Due to the limitations of Regulation 7, the research team does not know ***precise*** monitor readings at the ***exact*** moment Earthworks documented the pollution event. Regulation 7 only requires operators to provide an hourly aggregate reading for each metric they record rather than the minute-by-minute data that should come from CEMs.

Regulation 7 allows operators flexibility in which pollutants and metrics they record. However, it requires at least one of the following: "total VOCs, methane, benzene or BTEX (benzene, toluene, ethylbenzene, and xylenes) or other indicators of hydrocarbon emissions from pre-production and early production operations." Although there was some variation in which metrics were recorded from site to site and even from month to month, all of the sites in this study included total VOC (tVOC) emissions readings from their monitors. This metric also worked well for comparison with the Earthworks OGI camera, which also does not specify the different hydrocarbon emissions it detects.

Operators were also required to define response levels for the pollutants they monitor and the actions that would be taken if elevated levels were exceeded. Earthworks researchers chose to use these operator-defined thresholds as one of the criteria to define what was or was not a pollution event.

Comparing the data – Aggregate CEM readings vs. OGI

As monitoring reports became publicly available at the end of each month, Earthworks filed records requests with CDPHE. If pollution was detected with Earthworks OGI cameras, the team recorded it for at least 10 minutes. After recording, the team analyzed the video footage against well pad maps and other records operators filed with CDPHE to determine which CEMs on site would most likely detect the pollution event.

The team then reviewed the corresponding monthly monitoring report to determine if CEMs captured evidence of the same pollution event. For CEMs, Earthworks defined a pollution event as monitor readings that exceeded the operator's "Response Level Event" as defined in their AQMP or if any of the monitors at the time of OGI documented pollution reported a "Maximum" or "Mean" level more than four times the monthly average at that site. If CEM readings did not indicate a pollution event as defined above, it was counted as a failure to detect pollution. Notably, Project Canary's comments on the EPA's proposed supplemental rule regarding emissions guidelines for the oil and gas industry also suggest the use of OGI inspection to verify that CEM systems are operating correctly.[137]

Results:

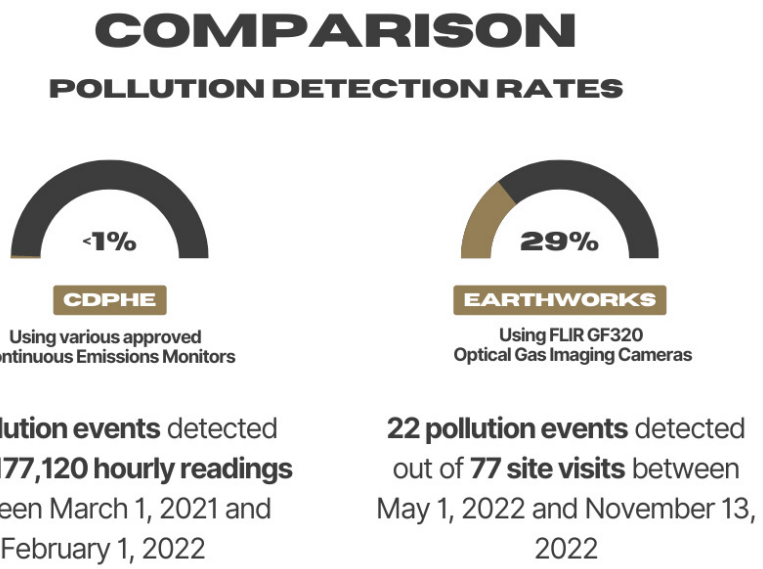
Using the approach defined above, we found that **0 of the 22 OGI documented pollution events were detected by the CEMs at surveyed sites.**[f] Furthermore, our review of 115 monthly monitoring reports

f Fourteen sites had Project Canary-S monitors, five sites had SENSE-IT SPOD monitors, two sites had Aeroqual AQS-1 monitors and one site had SGS SmartSense monitors.

found only one instance where monitors documented pollution that triggered agency notification and required operator actions as defined in their monitoring plan.[138]

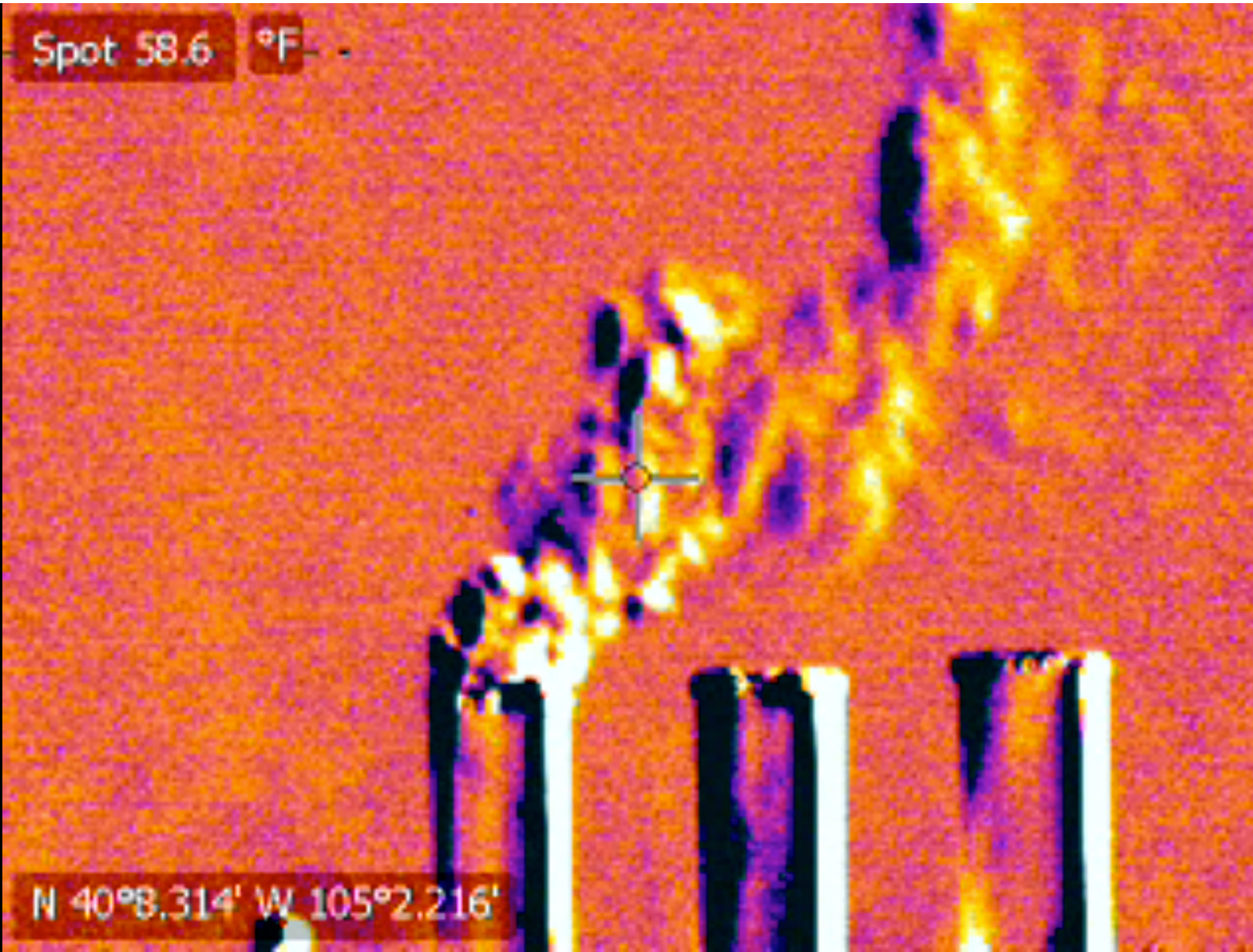
Most notably, there is a stark contrast between CDPHE documents, which only report 11 confirmed emissions events over roughly 177,120 hourly readings across all facilities that the CDPHE received (246 monthly reports from 28 facilities, which included 24 readings per day and ~30 days per month),[139] versus Earthworks' report of 22 emissions events from just 77 site visits over a period of 7 months which we believe should have triggered notifications.

Figure 5.4



Source: Earthworks

Extraction Rinn Valley combuster 2. OGI Image by Andrew Klooster, Earthworks - Weld County, CO - March, 2021



A CLOSER LOOK:

Below we will take a closer look at four of the sites at which Earthworks researchers detected and recorded pollution with OGI cameras. More information about all 22 sites can be found in Appendix B.

Noble Energy, LLC - DP 434 Guttersen C28

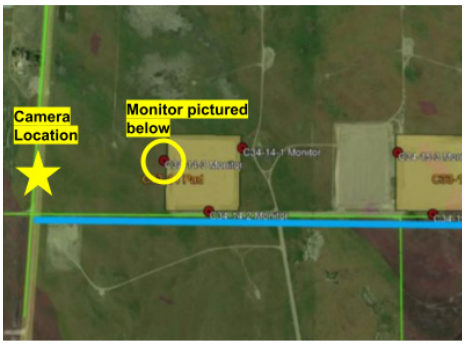
(40.262614, -104.560177)
Weld County, Colorado
Monitoring Began: 7/1/2022
Well Info
Air Quality Monitoring Plan
Monitoring Reports

Table 5.1 Guttersen DP 434 C28 Visit Log		
Date	**OGI Detection?**	**Canary Detection?**
8/30/22	Yes	No
10/26/22	No	N/A

At the time of Earthworks' initial visit on August 30th 2022, records indicated that several wells on the site were in the drilling phase of pre-production as confirmed by the field team based on assessments of equipment and activity at the site.[140] During pre-production, "sound walls" were constructed to reduce noise pollution. We observed that all monitors were placed outside of these sound walls (see Figure 5.5). A review of the AQMP for the well site confirmed that Noble intentionally placed these monitors outside of the sound wall and that this procedure was approved by CDPHE.[141]

Figure 5.5

Figure 5.6



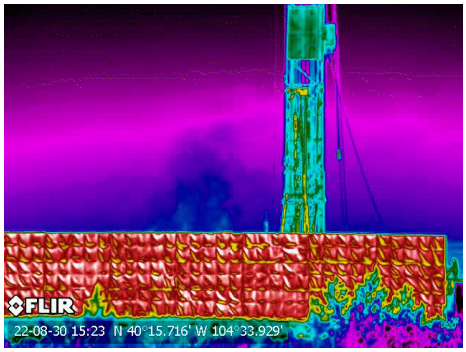
Earthworks FLIR GF320 camera detected significant uncombusted emissions coming from near the drilling rig at the center of the well pad. The emissions traveled upward and then in a WSW direction away from the camera's position East of the pad (Figure 5.6).

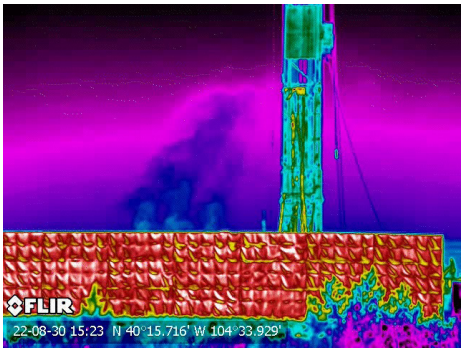
Due to the absence of smoke, steam, or opacity in the plume, and the characteristics of the plume when observed through the OGI camera, it was determined that the emissions were likely a mix of methane and other VOCs. Furthermore, the most likely culprit of these emissions was drilling engines on the surface of the pad, given the fact that there were multiple distinct sources of heat and uncombusted emissions in the form of plumes that cooled rapidly as they moved away from the sources behind the sound wall.

Findings for 08/30/22: All Canary-S monitors failed to detect the pollution event. None of the three monitors present at the site reached the "Event Response" Level of 3 ppm as defined in the AQMP submitted to CDPHE nor reached 4 times the average for that month.[142]

Table 5.2 shows the Minimum, Maximum, and Mean readings reported to CDPHE for each monitor during the hour in which the pollution event was documented and the average hourly Min, Max, and Mean reading for each monitor for the month of August.

Figure 5.7 Click here for video





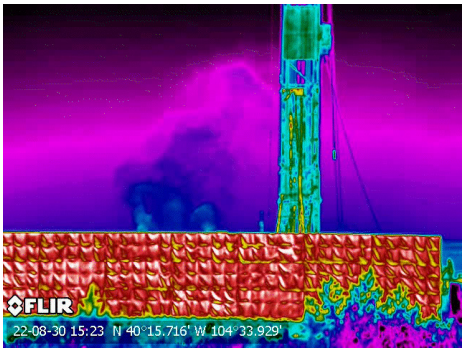


Table 5.2	Monitor Readings for tVOC (ppm) 08/30/22 - 15:00-16:00 MST			Avg tVOC (ppm) for August			Event Response Level
Monitor	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**	
NE	0.110	0.340	0.178	0.069	0.127	0.083	3 ppm
WNW	0.420	0.440	0.424	0.407	0.442	0.416	3 ppm
S	0.460	0.580	0.475	0.461	0.570	0.477	3 ppm

Data provided by monthly monitoring report submitted to CDPHE.[143]

Bayswater Exploration - Almont-Dotsero

(40.5991, -104.58455)
Weld County, Colorado
Monitoring Began: 10/1/2021
Well Info
Air Quality Monitoring Plan
Monitoring Data

Table 5.3 Almont-Dotsero Visit Log		
Date	**OGI Pollution?**	**Canary Pollution?**
8/29/22	Yes	No
9/28/22	No	N/A
11/12/22	Yes	No

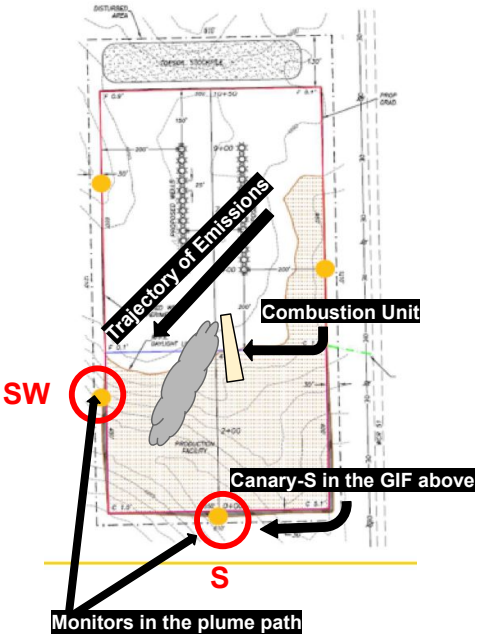
At the time of the initial Earthworks investigation on August 29th, 2022 records indicate that several wells on the site were producing oil and gas.

Earthworks FLIR GF320 camera revealed incomplete combustion of excess vapors occurring at the west most Enclosed Combustion Device (ECD) (see Figure 5.8). The uncombusted hydrocarbon pollution (likely VOCs and methane) escaped the ECD in a plume that traveled southwest toward one of the four Canary-S monitors at the site (see Figure 5.8) This monitor is clearly visible in the OGI footage pictured in Figure 5.9. However, because of the height of the combustor stack most of the pollution appears to rise above the sensor which is just 6 ft above the ground.

Findings for 8/29/22: All Canary-S monitors failed to detect the pollution event. None of the 4 monitors present at the site reached the "Event Response" Level of 3 ppm as defined in the AQMP submitted to CDPHE nor reached 4 times the average for that month.[144] In fact, all readings were below average at the time OGI recorded a pollution event.

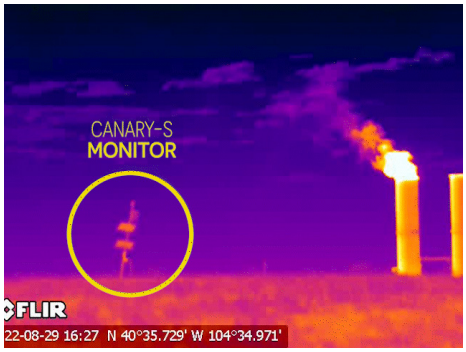
The graph in Figure 5.10 is the same data represented as a line graph, which illustrates two very important details. First, it shows that while there are gradual ups and downs throughout the month, tVOC (Total VOCs) levels are almost always an order of magnitude below the 3 ppm action threshold established by Bayswater in its AQMP – this is something seen across the board in the records we reviewed. Second,

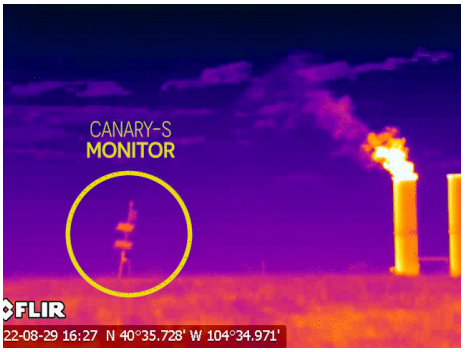
Figure 5.8



the data set from this monitor is missing a significant portion of data from the beginning of the month. In fact, this monitor (Called East or E in Bayswater's AQMP) had a monthly failure rate above 50% for the three months prior to our visit.[146]

Figure 5.9 Click here for video





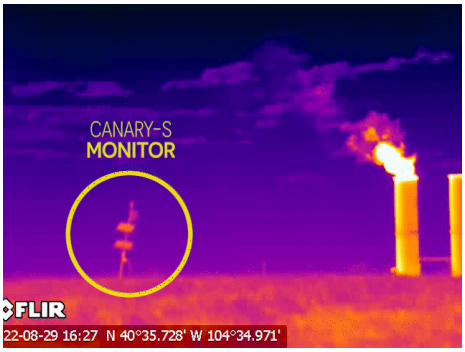


Table 5.4	Monitor Readings for tVOC (ppm) 08/29/22 - 16:00-17:00 MST			Avg tVOC (ppm) for August			Event Response Level
Monitor	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**	
E	0.250	0.290	0.271	0.239	0.311	0.254	3 ppm
NW	0.375	0.378	0.376	0.385	0.450	0.396	3 ppm
S	0.387	0.391	0.388	0.510	0.590	0.527	3 ppm
SW	0.339	0.395	0.351	0.749	1.335	0.938	3 ppm

Data provided by monthly monitoring report submitted to CDPHE.[145]

Figure 5.10

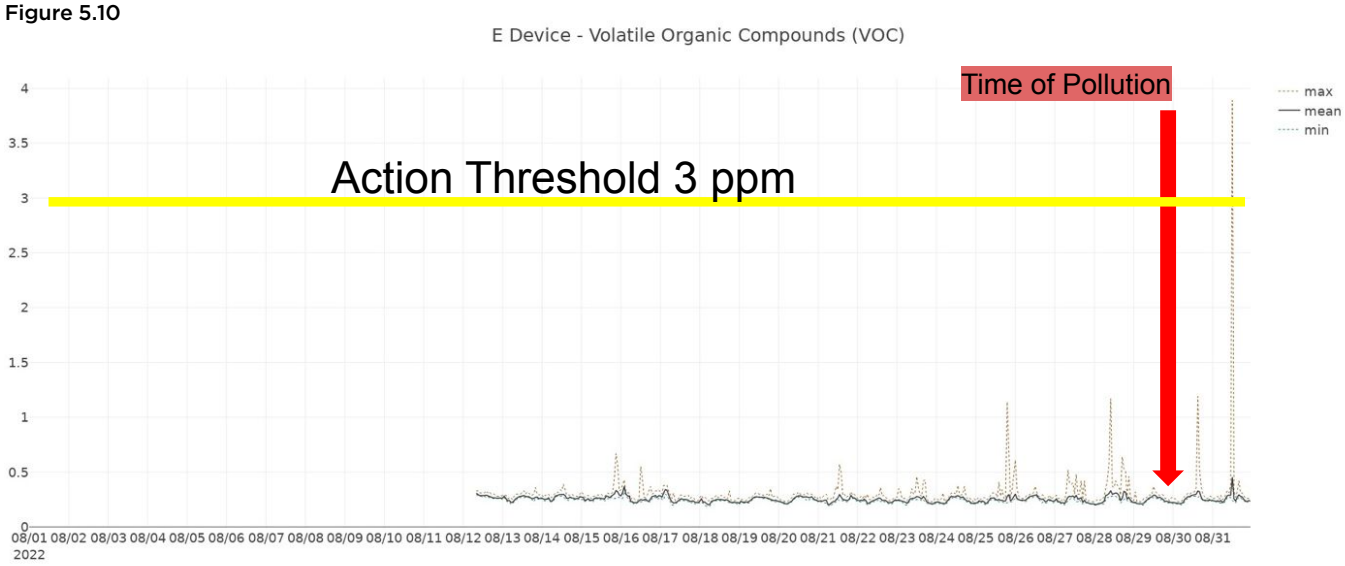


Image by Earthworks, Weld County, CO - August, 2022

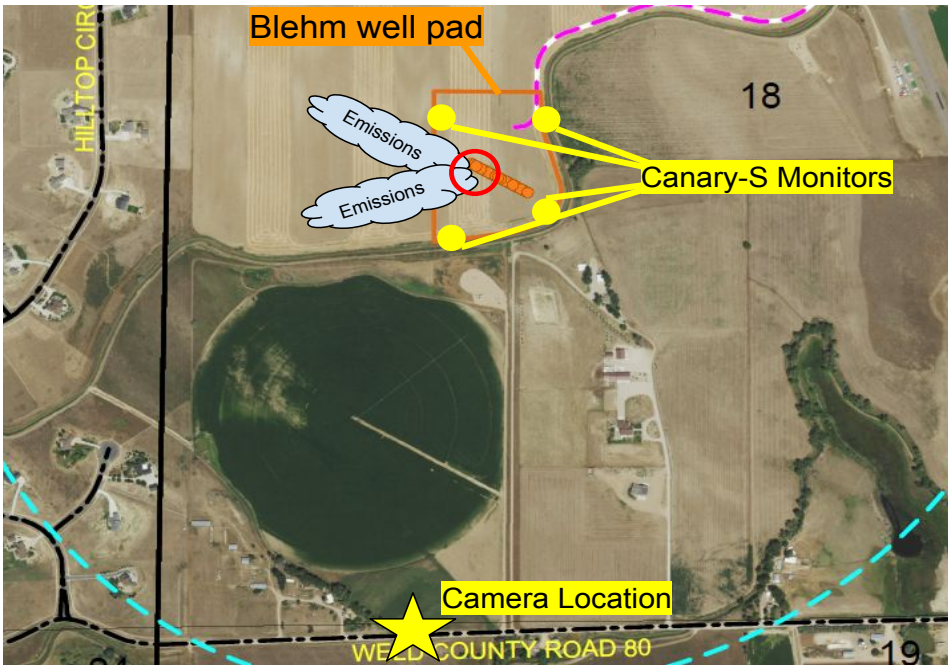
Bayswater Exploration - Blehm

(40.574363, -104.825924)
Weld County, Colorado
Monitoring Began: 11/1/2021
Well Info
Air Quality Monitoring Plan
Monitoring Data

Table 5.5 Blehm Visit Log		
Date	**OGI Pollution?**	**Canary Pollution?**
7/28/22	No	N/A
8/29/22	No	N/A
8/31/22	No	N/A
9/28/22	Yes	No
11/12/22	Yes	No

At the time of our investigation, wells on the site were moving from the fracking phase into active production of oil and gas.

Figure 5.11



Of all the sites surveyed for this report, Blehm was perhaps the most alarming. At approximately 4:20 pm MT November 12, 2022 Earthworks' FLIR GF320 camera detected significant and prolonged hydrocarbon emissions from what appeared to be the tank battery on the well pad (see Figure 5.12). A tank battery is made up of several tanks, which hold crude oil or produced water during the production of oil and/or gas. These liquids volatilize over time into methane and some of the most hazardous air pollutants like Benzyne, Toluene, Ethylbenzene, and Xylene (BTEX). The OGI was captured from south of the pad, and the plume was traveling westward, far off-site and towards a residential neighborhood (see Figure 5.11).

Following an inquiry by CDPHE (prompted by our official complaint) the operator claimed the emissions were due to an open hatch on one of the tanks, an egregious oversight by any measure.

Findings for 11/12/22: All Canary monitors failed to detect the pollution event. None of the four Canary-S monitors registered pollution levels above the "Event Response" Level of 3 ppm (as defined in the AQMP submitted to CDPHE) or reached four times the average for that month. In fact, all four monitors registered average or lower levels of tVOC at the time of the OGI recorded pollution event.

Figure 5.12 Click here for video

Table 5.6	Monitor Readings for tVOC (ppm) 11/12/22 - 15:00-16:00 MST			Avg tVOC (ppm) for November			Event Response Level
Monitor	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**	
ENE	0.246	0.250	0.248	0.265	0.376	0.280	3 ppm
NW	0.342	0.365	0.349	0.311	0.448	0.326	3 ppm
SE	0.460	0.469	0.465	0.532	0.796	0.570	3 ppm
SSW	0.355	0.360	0.358	0.329	0.488	0.351	3 ppm

Data provided by monthly monitoring report submitted to CDPHE.[147]

Crestone Peak Resources - Warner

(40.06725, -104.65842)
Weld County, Colorado
Monitoring Began: 7/1/2021
Well Info
Air Quality Monitoring Plan
Monitoring Reports

Table 5.7 Warner Visit Log		
Date	**OGI Pollution?**	**Canary Pollution?**
8/30/22	Yes	No
10/26/22	No	N/A
11/13/22	Yes	No

At the time of our initial visit on August 30th, 2022, the Warner site was actively producing oil and gas, and an enclosed combustion device (ECD) was burning tank vapors. During two of our three visits (August 30th and November 13th, 2022) to the site Earthworks FLIR GF320 camera revealed uncombusted pollution from ECDs at the east end of the pad. (see Figure 5.14).

At approximately 12:52 pm MT on our November 13th visit, the pollution from the ECDs formed a plume that traveled toward a Canary-S monitor at the Northwest corner of the site (see Figure 5.14). However, because of the height of the combustor stack and the upward movement of the plume most of the pollution appears to travel above the monitor, which is just 6 ft above the ground. This difference in source and monitor height is evident in Figure 5.13.[148]

Findings for 08/30/22: All Canary monitors failed to detect the pollution event. None of the three monitors present at the site reached the "Event Response" Level of 3 ppm (as defined in their AQMP submitted to CDPHE) nor reached four times the average for that month. In fact, all readings for all monitors at the time of the OGI recorded pollution event were below the average readings for the month of August.

Findings for 11/13/22: All Canary monitors failed to detect the pollution event. None of the three monitors present at the site reached the "Event Response" Level of 3 ppm (as defined in their AQMP submitted to CDPHE) or reached four times the average for that month. In fact, all readings for all monitors at the time of the OGI recorded pollution event were below the average readings for the month of November.

Figure 5.13

Figure 5.14

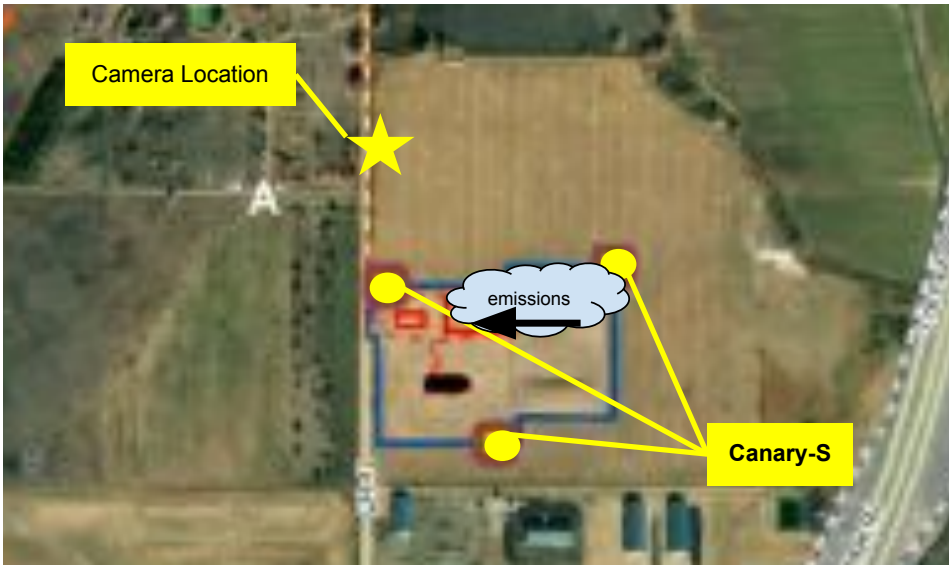
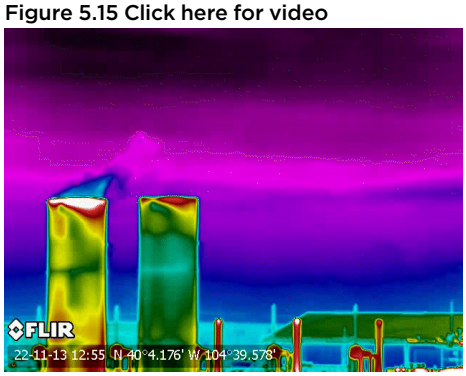
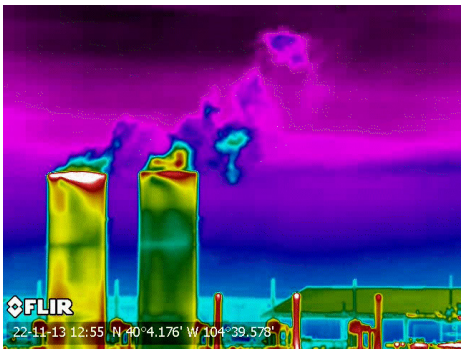


Figure 5.15 Click here for video





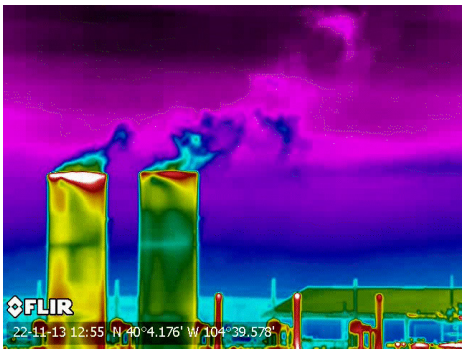


Table 5.8	Monitor Readings for tVOC (ppm) 8/30/22 - 16:00-17:00 MST			Avg tVOC (ppm) for August			Event Response Level
Monitor	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**	
NE	0.281	0.323	0.300	0.295	0.327	0.302	3 ppm
NW	0.291	0.307	0.298	0.355	0.399	0.368	3 ppm
S	0.389	0.424	0.397	0.408	0.447	0.416	3 ppm

Data provided by monthly monitoring report submitted to CDPHE.[149]

Table 5.9	Monitor Readings for tVOC (ppm) 11/13/22 - 11:00-12:00 MST			Avg tVOC (ppm) for November			Event Response Level
Monitor	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**	
NE	0.267	0.275	0.269	0.283	0.307	0.288	3 ppm
NW	0.229	0.244	0.237	0.276	0.336	0.288	3 ppm
S	0.300	0.310	0.304	0.342	0.390	0.352	3 ppm

Data provided by monthly monitoring report submitted to CDPHE.[150]

Conclusions:

Earthworks' survey is not designed to provide absolutely conclusive evidence. To do that would require more information from operators, monitor manufacturers, and CDPHE. However, our survey does provide an important, field-level comparison between technology that we know works (Optical Gas Imaging) and CEMs like the Canary-S.

This comparison covered a range of operators, emission sources, and emission sizes, yet all returned the same results: **monitors consistently failed to capture pollution events detected by OGI cameras.** Furthermore, CEMs rarely captured pollution at all.

What is more likely is that the monitoring methods and technology used under Regulation 7 are not truly capable of capturing most component-level pollution. Recent studies support this theory. One new study, which looked at a wide variety of continuous monitors, including the Project Canary-X monitor (which is superior to the Canary-S monitor present at sites in this study) showed that none could detect emissions with accuracy rates higher than 50% when emissions rates were between 0.1 – 1.0 kg/hr. This happens to be the range of "component leaks that would be routinely identified and fixed in OGI surveys."[151] In the field - where monitoring systems are exposed to practicalities like harsh weather, remote areas with limited service to transmit data, and interference from adjacent sources of pollution – accuracy would likely be even lower.[152]

Our survey also discovered a number of implementation issues that could further reduce any monitor's ability to detect pollution events.

1. **Physical barriers between monitors and sources of pollution**
   At many of the sites in the pre-production phase, operators chose to place the monitors outside of the 30 ft sound wall, just a few feet off the ground. In other words, there was a significant physical obstacle between the monitors and the sources of emissions. Figure 5.5 shows an example of this at the Nobel Guttersen C33 pad. While the physics of such a setup is obviously problematic, this monitoring placement was no mistake. Nor was it in violation of any rules. It was outlined in Noble's Air Quality Monitoring Plan, a plan developed with the help of their CEMs manufacturer, Project Canary. Furthermore, the plan was approved by the CDPHE before any activity on the well site began.

2. **Placement of monitors**
   We encountered many Project Canary sites where monitor setup did not reflect the setup used in the controlled tests cited by Project Canary as evidence their product works. In some scenarios,

Image by Earthworks, Weld County, CO - November, 2022

monitors were placed further away and lower to the ground than was described. For instance, at the Warner 10H-E165 well site, Canary-S monitors were an average of 551 ft away from the closest source of pollution (Figure 5.16).[153] However, in the study often cited by Project Canary, sensors were placed between 69 and 230 feet from sources.[154]

We also found occasions when irregular monitor placement allowed pollution to go undetected. During our visit to Bayswater Explorations Topaz 6-1 well site on July 28, 2022, we captured pollution blowing directly East. There were four Canary-S monitors on this site but none were placed to the East of the pollution source (Figure 5.17). This was likely a factor in monitors falling to capture pollution. This placement also conflicts with Project Canary's own recommendations to place monitors equal distances apart around the site.[155]

3. Number of monitors

All of the Project Canary sites we reviewed in our survey had fewer monitors than were present in controlled tests cited by the company. Sites in our survey had either three or four Canary-S monitors present. However, Project Canary uses eight monitors in the tests it cites on its website (shown in Figure 5.18).[156]

Our findings suggest that there is a considerable gap between Project Canary's rhetoric and reality, and if this is true, it would have significant implications. As we have already laid out, Project Canary is aggressively promoting its services as "radically transparent" and proven to lower emissions. The reality is that information about and data captured by their monitors is extraordinarily hard to find and often misrepresented. Oil and gas operators using Project Canary's services may misrepresent their products. In Colorado, we have observed that operators are already successfully using monitor data as counter-evidence against complaints filed by communities living near these major sources of pollution and certified thermographers' OGI footage. Meanwhile, there are very few avenues to hold Project Canary accountable.

Figure 5.16

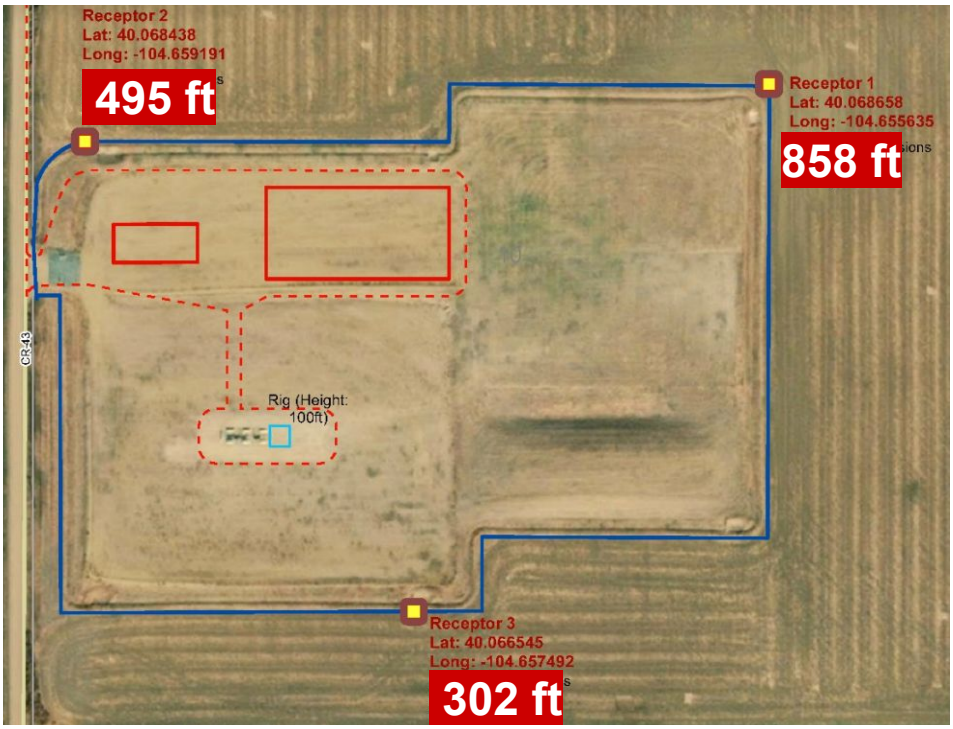


Figure 5.17

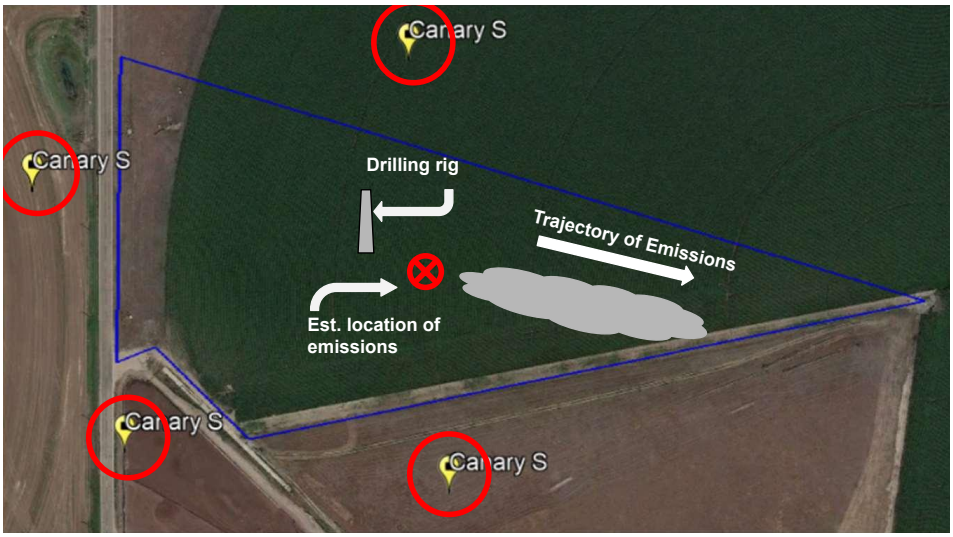
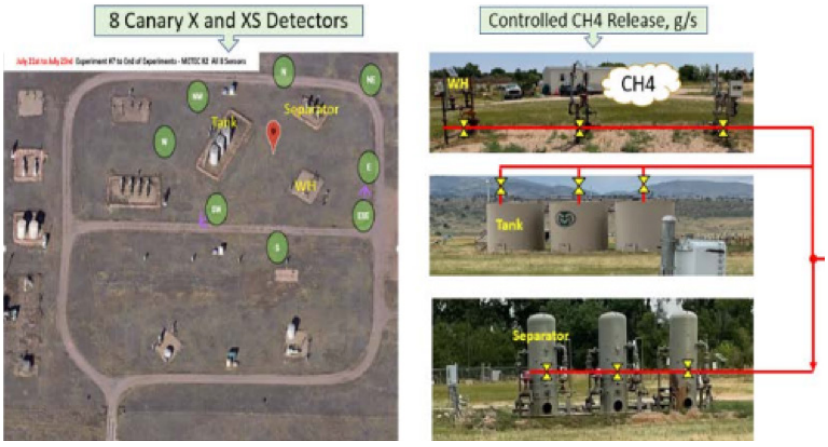


Figure 5.18



EXPERTS ARE SKEPTICAL OF SENSORS AND EMISSIONS QUANTIFICATION METHODS

Evidence from the Earthworks survey reflects concerns expressed by leading atmospheric science and methane monitoring experts interviewed for this report about the current state of methane monitoring and certification. Interviewees were not aware of the Earthworks survey findings.

Several experts point out how complicated it is to perform constant methane monitoring and obtain reliable and accurate data. "Methane monitoring is an incredibly difficult task and needs a high level of expertise and transfer of best practice and knowledge from academics," says Professor Grant Allen, an airborne and satellite methane monitoring expert from Manchester University in the UK. "Some of these schemes don't have that. There is quite a way to go for these systems to work well."[157]

"There are two different challenges," says Allen. "Leak detection of fugitive emissions – you can do that easily with relatively low skill and at low cost. Quantifying emissions is still a tall order though, requiring expensive research-grade instrumentation and measurement surveys tailored for individual emitters."

Several of the academics and experts we spoke to state that the only way to monitor methane effectively is to use a variety of techniques, including airplanes, drones, sensors, and cameras. Moreover, different monitoring technologies will work better at different geographical locations as well as with the varying equipment used along the lifecycle of oil and gas production and transportation. "There is no one-size-fits-all approach" for methane emission monitoring, says Professor Allen.[158]

One reason that there is no one size fits all for the oil and gas industry in the U.S. is that certain shale gas basins leak methane at different rates than others. In an interview, another leading methane expert, Arvind Ravikumar, a Research Associate Professor from the University of Texas, says that "Different basins have different methane leaks. Gas from NE Pennsylvania is different from the Permian, which has higher methane rates," he says. "Some basins have to do much more work" to detect leaks.

In a recent peer-reviewed publication, Ravikumar and his coauthors concluded, "no currently existing technology is sufficient on its own for capturing the temporal fluctuations of methane emissions, which is necessary to develop accurate annual emissions estimates."[159]

Experts and academics all took issue with the certifications schemes too. Ravikumar says that the U.S. does have the "wild west of certification schemes." He argues that "Certification schemes are not standardized or transparent" but "that the industry is heading in that direction."

Drew Shindell is an ex-NASA professor of Earth Science at Duke University. He has authored over 250 peer-reviewed publications and received numerous awards. Shindell says: "I would not trust current certification schemes that claim to do direct atmosphere monitoring. They only cover a small area and are often deployed at the best-performing sites. They assume there is an average when it comes to methane emissions. They don't get a representative sample. Ideally, we need remote sensing from satellites and planes combined with cameras and sensors."[160]

Even those in the industry believe that a combination of technologies is needed. In an interview with CNBC in January 2023, Georges Tijbosch, CEO of Project Canary's competitor, MiQ, reiterated what many experts had told us: "It is actually quite complicated to do it properly on determining methane emissions. There are a variety of technologies that are out there, but none of the technologies actually is able to properly do it in one go and have that absolute kind of precision."[161]

Aaron Van Pelt from QLMtec, which has developed methane camera sensors, says, "Different technologies may work better in one location versus another. For example, for oil wells, it might be point sensors such as cameras; for gas utility pipelines, the best way to measure them is to drive the streets or use drones or helicopters, or planes if you cannot drive. There is no silver bullet. Every technology has a sweet spot and has limitations."

He adds that point sensors "don't give location specificity. Cameras are best." However, sensors are often used as they are cheaper than cameras. "A lot of people would agree that all the technologies – point sensors, drones, and satellites – will be needed for progress to be made. There is no single solution yet," he says.

Van Pelt argues that the emissions reduction landscape is a patchwork of certifications and regulations and is akin to the "wild west."[162]

Indeed, one former industry insider who prefers to remain anonymous told us that "regulation on methane is extremely necessary."[163] Their concerns echo those raised in an in-depth article in Canary Media on the industry, published in January 2023: "The green-gas market at this point is a Wild West frontier filled with mudslinging and smoke and mirrors – and the gunslingers are deciding the rules as they go along."[164]

You can see why this is the case. The evidence from the field and testimony of leading experts in the emissions monitoring space suggest that further scrutiny and oversight of Project Canary's methods are needed. If monitors frequently fail to detect emissions events and are inadequately sited for comprehensive emissions detection, can a site's emissions rate be calculated with confidence? If leading experts agree that accurate emissions quantification requires a suite of tools and measurements, can we trust Project Canary's certification of a site or a supply chain when it relies on a handful of sensors with limited quantification abilities? If even these limited tools are placed inadequately around a site such that emissions plumes are frequently beyond the sensors' range, how much value can we really place on the data behind certification?

Even the industry disagrees over which technology and approach work best. The CEO of MiQ, a rival company to Project Canary, has criticized the company for undertaking continuous monitoring, which he claims "is a red herring" because in the field, technology "doesn't always work right."[165]

6. TRANSPARENCY AND ACCOUNTABILITY

Project Canary's mission statement states, "We believe in the power of science, the importance of transparency and that accurate, independently collected data is critical to driving a clean energy future." It says the company's "commitment to these ideals means that our ESG data can be trusted by partners, investors and the general public."[166]

However, independent experts and assessments and our own investigation point to major shortcomings in transparency, as well as conflicts of interest between Project Canary and the companies whose gas it certifies, all of which cast doubt on such claims.

Project Canary claims that it has adequate third-party verification for its activities. It states that working with the Payne Institute at the Colorado School of Mines and a big four accountancy firm, in the company's own words, adds "performance proof verification of data and operating standards."[167] But the data is not made available for public verification, and Project Canary's methods have not been subjected to peer review.

Project Canary is also promising to bring "radical transparency" to the industry by using blockchain technology. For example, in November 2022, Project Canary announced it was working with ENGIE Energy Marketing and BKV Corporation to develop a framework and marketing program to develop a new product for an emerging U.S. market on Carbon Credits associated with measured Carbon Sequestration."[168]

Blockchain technology is increasingly being used by the methane certification industry. Some companies are uploading monitoring data onto a designated platform, which are then transformed into "emissions tokens" that can be traded. Project Canary argues that the use of such technology will increase accountability and bring "radical transparency" to the gas certification market.[169] But simply publishing a spreadsheet would be the most accessible means to bring transparency.

In August 2022, the Calgary-based consultancy Highwood Emissions Management issued a report that examined the fast-growing methane certification industry and concluded that "Despite a rapid increase in the number of certifications, initiatives that require more work, expense, and transparency remain less popular. A preference remains for less stringent initiatives that protect company data, lower exposure, and require less investment of time and money – despite the increased risk of greenwashing."[170]

Findings such as this concern experts who have repeatedly told us that transparency and total independence from the gas industry are crucial to the integrity of gas certification. There is a need, they say, for complete data transparency and independent verification, with results subjected to peer review.

"At the moment, proprietary quantification methods can be a bit of a black box, and it's not easy to get information on the methods used," argues Professor Allen. "So it needs academic oversight but with the process being led by regulators to ensure compliance. And methodologies should be peer-reviewed. The emissions data should be public – at least to regulators. This would be the gold standard that could build trust and transparency in any data."[171]

Arvind Ravikumar also says there cannot be a "black box." "If you want people to trust you, models have to be transparent."[172] In a peer-reviewed article, Ravikumar and others argued that "currently available frameworks do not provide the level of transparency and rigor to be able to build trust among the public through independent, third-party verification."[173]

This third-party verification of the analysis undertaken by a certifying company, such as Project Canary, either via independent peer review or published data, is crucial. One expert, who prefers to remain anonymous, states that "the claims that Project Canary is making regarding being able to track all methane emissions seem to be premature and should be backed up by peer-reviewed science so they can be independently validated."[174]

David Lyon is a methane expert, who when interviewed worked with EDF. He concurs, saying, "If natural gas certifiers want the public to have confidence that their methane intensity metrics are legitimate, then they should use transparent, measurement-based emissions quantification that is verified by independent third parties, limits cherry-picking of assets, and sets ambitious mitigation targets that are complementary with regulations."[175]

Without this independent scrutiny of the data and methodology, questions will remain over the veracity of the data. Other methane experts at EDF noted in May 2022 that "accurately quantifying a company's methane emissions is tricky. And none of the oil and gas companies or their consultants have devised a way to do it that creates sufficient confidence that these certifications are meaningful."[176]

Comparative rankings of different certification schemes are rare. But the Highwood emissions report did rank the transparency of the leading certification initiatives, including Project Canary's TrustWell scheme and its competitors at Equitable Origin, MiQ Foundation, and Xpansiv (although Project Canary

does work with Xpansiv). In none of the categories did Project Canary score the highest ranking for transparency and was often ranked lower than its competitors.[177]

HOW INDEPENDENT IS PROJECT CANARY?

The company makes several bold claims about its independence on its website. Project Canary says it is "fiercely independent" and "a trusted, honest, ethical, and truly agnostic third party to the whole energy value chain."[178] It labels its TrustWell analysis as "the most trusted and independent certification" on the market today.[179]

The company lists several key attributes of its Responsibly Sourced Gas certification scheme on its website.[180] One of them reads, "Certification must be accompanied by verification from a credible and independent third party." At the top of a check-marked list of ways the company ensures this is, "Project Canary is a credible and independent third party and retains ownership of all sensors to ensure accuracy and performance."[181]

Some may argue the entire premise of Project Canary's business model sets up a conflict of interest. After all, all parties share a financial interest in the process. There is compelling evidence CEO Chris Romer, who owns the bumper sticker "the last Democrat for fracking," is a cheerleader for the U.S. shale industry and is focused on restoring its "social license to operate."[182]

Aside from this generic conflict of interest, our investigation has found that a key Project Canary DIrector and Advisory Board Members have direct financial interests in the same gas companies it certifies. At least one of the company's investors is also heavily invested in its customers. While there is no evidence of any impropriety, the close ties between a key board and Advisory Board members and investors and the company's customers raise questions about whether Project Canary can be considered independent enough to be certifying such a crucial element of a company's environmental performance, particularly when such certification can earn the company a premium for its product. Arvind Ravikumar, from the University of Texas, says, "fundamentally, there is a conflict of interest if an oil company is paying you to certify their emissions."[183]

POTENTIAL CONFLICTS OF INTERESTS OF THE BOARD

Jeffrey Harris and Quantum Energy Partners

Jeffrey Harris is on the Project Canary board. In 2012, he founded the Global Reserve Group, an investment and advisory firm "focused on the intersection of the technology and energy industries."[184] That same year, he became a Venture Partner of Quantum Energy Partners, an energy-focused private equity firm, where he sits on the Investment Committee. In June 2022, Project Canary announced that it had "expanded its strategic relationship with Quantum Energy Partners."[185]

Quantum is, according to Bloomberg, "one of the pre-eminent private equity firms in U.S. oil and gas."[186] At least three of the companies in which Quantum invests are Project Canary gas certification customers.

Rockcliff Energy: Quantum's Website says, "today Rockcliff is one of the largest privately-owned natural gas companies and currently produces more than 1 Bcf/d of responsibly sourced natural gas".[187] In April 2022, Rockcliff Energy announced an "ongoing commitment to utilize" Project Canary for "independent monitoring, emissions measurement, and environmental, social, and governance (ESG) certification of its natural gas production assets."[188]

Tug Hill and XCL Midstream: THQ is a partnership set up between Tug Hill and Quantum to develop the Appalachian Basin. Quantum has invested over $1 billion into THQ businesses.[189] In December 2021, it was announced that "Tug Hill Operating, and XcL Midstream Operating, will seek responsibly sourced gas (RSG) certification for the entirety of their upstream and midstream assets via a partnership with Project Canary …. Tug Hill and XcL, which principally operate in West Virginia's Marshall and Wetzel counties, will be the first upstream and midstream companies to jointly seek independent certification of 100 percent of their operating assets …Both companies are privately held and partners with Quantum Energy Partners."[190]

Antero Resources: Antero Resources is in a $500 million drilling partnership with Quantum Capital Solutions fund, which is an affiliate of Quantum Energy Partners.[191,192,193] Antero is the fifth largest producer of natural gas in the U.S. and one of the top LNG suppliers, based in Denver, Colorado.[194] It is also a Project Canary client. In February 2022, Antero Resources announced its 4th Quarter results from 2021. In the release, the company states: "Received Responsibly Sourced Gas certification following completion of initial Project Canary Pilot. This rigorous independent assessment and certification process evaluated the engineering, operational, and environmental standards Antero employs in its operations."[195]

POTENTIAL CONFLICTS OF INTEREST OF THE ADVISORY BOARD

Tom Tyree: Tom Tyree is on the Advisory Board of Project Canary.[196] His biography states: "Mr. Tyree serves as Chairman of Northwoods Energy, which he founded in January 2018 with members of Apollo Global Management. Northwoods owns and operates oil and gas properties in the Powder River Basin of Wyoming. Mr. Tyree also serves as a director of Antero Resources,[197] which is a Canary client that was awarded new fracking licenses in Pennsylvania in April 2022.[198]

Carrie Hudak: Carrie Hudak joined Project Canary's Advisory Board in October 2019.[199] Hudak is a long-term oil and gas executive, who also serves as an Independent Director for Civitas Resources, including acting as Chairman of the company's ESG Committee.[200] Civitas, which is a Canary client,[201] is Colorado's "largest pure-play energy producer." The company claims it is "helping ensure our state and our communities will benefit from Colorado's oil and natural gas industry today and well into the future."[202] To this end, Civitas operates shale gas wells in over 500,000 acres of the Denver-Julesburg basin in Colorado, producing some 160,000 Boepd.[203] Working for the shale company, Project Canary is monitoring emissions for 42 of the 410 orphaned wells in Colorado that Civitas is plugging, located in and around the Company's areas of operations.

So despite Project Canary's claims of being the "leading independent certifier"[204] in the U.S, questions remain about its business model, including advocating for gas expansion and potential conflicts of interest of key personnel.

7. GAS CERTIFICATION AND CLIMATE GOALS

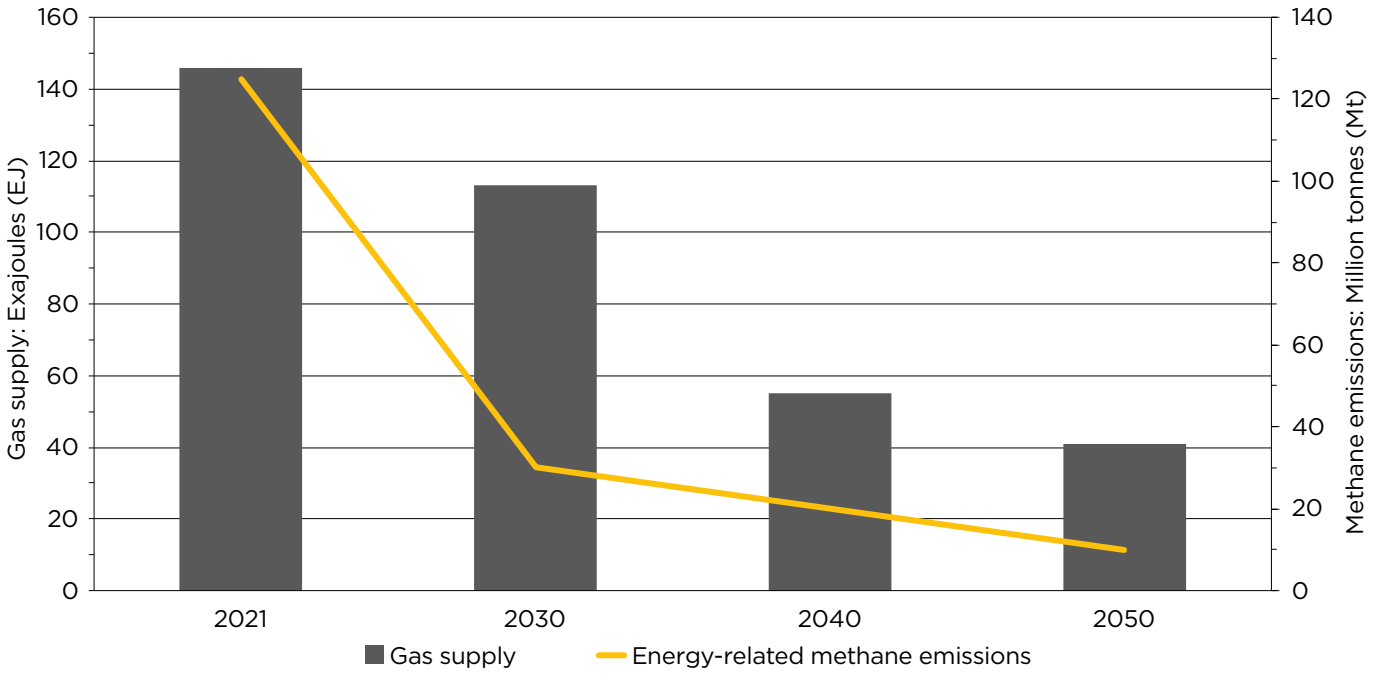
Ultimately, the most critical step to curtailing the climate crisis and protecting public health is phasing out fossil fuels entirely. Credible climate scenarios clearly show that gas production and consumption must decline this decade in tandem with rapid reductions in coal and oil.[205, 206] Research further shows that the oil and gas within extraction projects the industry has already developed would take the world beyond 1.5°C of warming, even if coal production stopped overnight.[207] Thus, the first logical step towards phasing out gas is to stop building new infrastructure to extract, emit, and burn it. In so far as gas certification is used by the industry, investors, or policymakers as a justification for expanding or prolonging gas extraction and infrastructure, it is a scheme that risks sabotaging rather than serving global climate goals.

NO SUBSTITUTE FOR PHASING OUT GAS

Rapid action to reduce methane emissions must be part of a managed phase-out of methane gas, not a substitute for it or an excuse to delay it. Figure 7.1 illustrates this reality using data from the International Energy Agency's 2022 World Energy Outlook. In the IEA's 1.5°C-aligned energy scenario, the Net Zero Emissions (NZE) scenario, staying within the 1.5°C limit requires both a 75% reduction in energy-related methane emissions by 2030 *and* a more than 20% reduction in gas production and use by 2030 (relative to 2021 levels). Additionally, no new gas fields or LNG export terminals are developed.[208]

While the IEA's NZE scenario shows the phase-out of gas must begin immediately, it also relies on radically optimistic projections for CCS deployment.[209] Avoiding or minimizing the risk that the high expectations for CCS may not be realized would require faster action to phase out gas. 1.5°C-aligned pathways that avoid reliance on risky technologies such as fossil CCS show declines in gas production as large as nearly 50% by 2030.[g]

Figure 7.1: The Decline of Gas Supply and Methane Emissions in the IEA's 1.5°C Energy Scenario



Source: International Energy Agency (2022)[210]

g For example, the Low Demand Illustrative Mitigation Pathway featured in the Working Group III contribution to the IPCC's 6th Assessment Report, which excludes reliance on either CCS or carbon-dioxide removal technologies in the energy sector, shows both oil and gas falling by 47% by 2030, relative to 2020 levels. Edward Byers et al., AR6 Scenarios Database hosted by the International Institute for Applied Systems Analysis, 2022, [link]; Arnulf Grubler et al., "A Low Energy Demand Scenario for Meeting the 1.5°C Target and Sustainable Development Goals Without Negative Emission Technologies," *Nature Energy* 3, June 4, 2018, pp. 515–527, [link].

A NEW FORM OF CLIMATE DELAY AND DISINFORMATION

We must now phase out all fossil fuels at such a steep rate partly because the oil and gas industry and other fossil fuel interests have knowingly blocked, delayed, and undermined efforts to act on the climate crisis for the past three decades or more.[211,212,213] Statements from prominent gas lobby groups as well as Project Canary itself suggest that gas certification risks becoming another tool in this playbook: a smokescreen to make it appear that oil and gas companies are beginning to clean up their act even as these same companies continue investing in new gas extraction and infrastructure that makes the climate crisis worse and obstructs the necessary phase-out of fossil fuels.

Leaked documents from the International Gas Union (IGU), the lobby group for the international gas industry, outline how the objectives of its public relations campaigns include the need to "increase" the "social acceptance of natural gas." One of the ways the IGU wants to do this is by branding methane gas as low carbon and positioning it "as a necessary part of the solution and as a vital component of the world's future energy mix."[214]

After examining these documents, the watchdog, InfluenceMap, noted that IGU's "commitments to methane reductions appear to be considered important for the public image of [methane] gas and the gas industry."[215] Indeed, one former industry insider we talked to said that positive messaging around methane certification was useful for the oil and gas industry to help it retain workers who might be concerned about climate change.[216]

Similarly, the American Petroleum Institute (API), the main lobby group for the U.S. oil and gas industry, also talks about how differentiated or "responsible" natural gas is becoming increasingly important "in ensuring natural gas continues to be viewed as a major component of a lower carbon energy future."[217]

Comments made by Chris Romer and Project Canary mirror the sentiments by the IGU and API. Romer has talked of the need to fix the gas industry's "brand problem"[218] and how certifying gas as "responsibly sourced" helps restore the industry's "social license to operate."[219] To this end, one of Project Canary's main marketing themes is that the certification of methane emissions and the growing measurement economy is a crucial strategy to achieve "net zero" or even "real zero."[220] However, despite such claims, Project Canary does not specifically require its clients to have a net zero target, according to an Energy Evolution podcast from S&P Global Market Intelligence, which interviewed Chris Romer.[221]

Such statements, therefore, point towards gas certification first and foremost as a branding strategy for the gas industry – as a tool to sustain the world's use of gas rather than to phase it out within climate limits. Project Canary's online channels and advertising put the idea of 'net zero' front and center,[222] claiming the company's certification service is part of the solution to get to 'net zero' emissions.[223] However, the idea that gas can be 'net zero' is in itself greenwashing. The only credible way to reach zero emissions from gas is to stop extracting and burning it.

THE ONLY "ZERO EMISSIONS" GAS IS GAS LEFT IN THE GROUND

The gas sector presents a twofold approach to achieving so-called "net zero" gas. Firstly, methane emissions are monitored and then hopefully eliminated. Secondly, the remaining carbon emissions from burning gas are either offset or addressed using Carbon Capture and Storage (CCS).

Leading scientists and experts rebuke the concept of "net zero" gas. In July 2022, scientists wrote in the prestigious journal *Nature Energy* that "a fossil fuel with a high climate impact" such as gas "cannot be a solution towards a zero-emission future."[224] They added, "Even greater monitoring, detection and reduction of methane leakage events will not stop the need for a "strong reduction in natural gas consumption" because "natural gas is still a fossil fuel that emits large amounts of CO_2 during combustion, in addition to fugitive methane emissions."

When it comes to zeroing out carbon pollution from gas, offsetting, carbon credits, and CCS have failed to produce meaningful progress to date – and, in some cases, are linked to worsening pollution.

Offsets are designed to compensate for, not directly reduce or eliminate, emissions. Numerous studies have shown they fail at producing real-world results.[225,226,227,228] In September 2022, the Oxford Institute of Energy Studies, which examined the use of offsets by the U.S. LNG industry and the issuing of carbon credits, criticized the process for its lack of transparency and credibility.[229] Four months later, a joint Guardian investigation found that more than 90% of rainforest carbon offsets supplied by the world's biggest provider "are worthless" and could exacerbate climate change.[230] Given this track record, global 'net zero' benchmarking standards, such as the Science-Based Targets Initiative, do not accept offsets or carbon credits as substitutions for a company directly reducing carbon pollution from its business operations or products.[231]

CCS is not a "net zero" solution either. At present, operating CCS projects globally capture less than 0.1% of annual carbon pollution from fossil fuels.[232] Drew Shindell from Duke University says, "The problem with the argument that we don't have to phase out gas because we will have hydrogen or CCS is that we don't know if hydrogen and CCS will ever become feasible at scale. It's the equivalent of buying a new house and new car on the assumption that in ten years I will have a new, higher paying job."[233]

James Dyke from the University of Exeter says, "The bottom line message here is that the greenest [methane] gas is gas that is left in the ground. You don't have a problem leaking methane emissions if you don't extract it. Given how razor thin the carbon budgets are for avoiding dangerous climate change, there aren't any credible arguments that gas can continue to play a significant role."[234]

GAS CERTIFICATION AS GREENWASHING

Gas certification contributes to greenwashing if and when used to portray gas as part of the 'solution' to the climate crisis, somehow compatible with a 'net zero' future or a substitute for immediate action to phase-out gas extraction and use. Unfortunately, Project Canary's public communications repeatedly position its services in that light, claiming the company can "provide net zero proof with trusted

data"[235] and posting media articles with headlines such as "Carbon-Neutral LNG: Another Reason Why Natural Gas Could Win 'The Energy Transition'"[236] and "Project Canary Helps Companies Make the Journey to a Net-Zero World."[237]

Project Canary clients have seized on similar framing. BKV states its tie-up with Project Canary will mean BKV becomes the "first certified net-zero natural gas and electric power producer in the U.S."[238] Civitas Resources, another Project Canary client, calls itself "Colorado's first carbon-neutral energy provider."[239] A third, Tallgrass Energy, aims to offer the first "carbon-neutral" gas to the Midwestern markets.[240]

Ultimately, what is needed from the oil and gas industry to curb the climate crisis is immediate and rapid action to reduce both methane pollution and oil and gas production within this decade. If business-as-usual carbon emissions continue to 2030, scientists indicate that the 1.5°C warming limit could be breached in less than ten years.[241] While several oil and gas companies, including the majority of Oil and Gas Climate Initiative members, have made some form of "net zero by 2050" pledge, none have definitively committed to reducing their total production and sales of oil and gas by 2030, and most are on track to increase oil and gas extraction. Previous Oil Change International analysis has shown that oil and gas majors' climate plans are grossly insufficient compared to what is required to hold warming to 1.5°C.[242] Gas certification alone cannot change this reality and should not be used to hide or distract from it.

Image by Earthworks, Weld County, CO - August, 2022

8. CONCLUSIONS AND RECOMMENDATIONS

Our investigation of Project Canary suggests the company is misrepresenting some critical aspects of its business. The company says it "accelerates progress to net-zero with continuous monitoring and uncompromising certification technology."[243] However, we lay out significant evidence that Project Canary's monitoring technology, when deployed in the field, fails to capture methane and VOC pollution at well sites. Conversations with experts and ongoing studies of continuous emissions monitors further support our evidence from the field.

Meanwhile, the certification market is rapidly growing. Proponents claim that as much as 50 percent of U.S. gas could be "certified" in the next few years,[244] reaching 100 percent by 2030.[245] Some companies are already using certification status to convince ESG-minded investors of their progress toward climate goals. Others are now selling certified gas to utilities at a premium, a cost which is then passed on to end-use consumers. In the U.S., LNG exporters are currently leaning on certifications to woo global purchasers who want lower-emission methane gas.

We find it likely that many of these decisions – which have global implications – are being made on dangerous pretenses. This report demonstrates that, at this point in time, gas certification is not the "organic certification" of gas it claims to be. Rather, it is a participation trophy based on distorted data collected by a company with potential conflicts of interest operating without oversight. This trend will continue as long as certification remains an industry-led, market-driven approach. It requires robust and rigorously enforced regulation that ensures absolute emissions reductions.

Accurately measuring and reducing the prolific pollution associated with oil and gas production, processing, transportation, and use is fundamental to slowing the climate crisis. But simply reducing this pollution is not enough. All credible climate scenarios show that methane emissions reduction must happen alongside an immediate phase-out of oil and gas production, not instead of it. To do that, all efforts to certify oil and gas emissions must start with a plan to end oil and gas production.

There are a number of regulatory agencies that have the authority to prevent the global consequences of the gas certification process overstating emissions reductions and understating the climate impact of methane. Our recommendations are listed below, followed by a discussion of which regulatory agencies should undertake them. Until all of these criteria are met, gas certification programs should cease.

Recommendations

- Companies undergoing certification have a clear, independently accredited plan to end fossil fuel production, including 5-year milestones which they must meet to maintain certification status.
- CEM manufacturers and distributors subject products and services to independent, peer-reviewed studies to ensure an accurate assessment of their capabilities. Such studies must be publicly available.
- Certifiers use CEMs that have been shown through independent peer review to meet the following minimum requirements:
  - Provide minute-by-minute readings of methane emissions measured in mass over time (kg/hr).
  - Demonstrate accurate detection and quantification of point source emissions of 0.1 kg/hr or higher with 90% confidence.
  - Maintain a 12-month rolling average of less than 10 percent operational downtime in field conditions.
- The certifier guarantees that implementation of monitors in the field matches conditions tested in peer-reviewed studies (e.g., number and placement of monitors related to type, size, and location of the site).
- Certification is obtained on a site-by-site basis rather than on a company-wide basis. Additionally, the certifier makes details of any certified site (i.e. type, quantity, and placement of monitors) publicly available and grouped by company.
- The certifier requires operators to submit monthly, site-specific monitoring reports for all certified sites to maintain certification. These reports must be publicly available and include the following:
  - Evidence of calibration.
  - Description of monitoring equipment deployed, including manufacturer and model.
  - Number and placement of monitors (including height) and meteorological measurement devices.
  - Topographic map of site.
  - Raw stream of minute-by-minute monitor data for all parameters measured.
  - Number and date of pollution threshold exceedances.
  - Full list of monitor failures, power outages, and connection losses.
  - Verified chain of custody.

- The certifier publicly discloses company performance details such as the number of wells or sites monitored versus unmonitored, the amount of oil and gas production certified versus uncertified, total measured emissions, violations, and improvement in absolute emissions reductions over time.

- The certifier takes immediate action to ensure board members, senior management, and staff have no financial ties or investments in the companies being certified.

Regulators

Regulatory agencies in the U.S. and Europe must act quickly to protect consumers, improve public health, and limit the worst impacts of climate change.

The EPA is currently finalizing rules for new and existing sources of oil and gas pollution, which includes a pathway for new technology such as CEMs in LDAR protocols. Individual states will then use these standards to develop implementation plans with details regarding how state regulators enforce these standards. In addition to the recommendations above, the EPA should create guidance regarding how state regulators must handle conflicting evidence from two or more types of technologies (e.g., if OGI captures pollution but a monitor does not). There may also be an opportunity for states to bridge gaps in the EPA's standards to ensure accurate measurement, disclosure, and reporting.

Likewise, the FTC is currently undergoing a regulatory review of its "Green Guides," which provide general and specific principles for environmental marketing. This is an opportunity to craft guidance that prohibits all consumer-facing claims relating to certified gas unless accompanied by certain disclaimers/disclosures.

Additionally, the DOE is considering minimum standards for U.S. gas certification. It is our recommendation that the department only engage in setting such standards if they meet the recommendations above.

If each of these agencies continues to put forth new standards and regulations regarding the use of CEMs and gas certification programs more broadly, we strongly advise they incorporate the recommendations outlined above, with specific attention to including a verified pathway to end production with milestones, increasing transparency of underlying data and methodologies, and mandating absolute emissions reduction.

As certified gas and associated environmental tokens are increasingly traded in international markets, we recommend the Commodity Futures Trading Commission develop and implement relevant rules and regulations in accordance with the recommendations above.

Regulators and customers in international markets purchasing U.S. LNG should not accept gas certificates from the U.S. unless they conform to the recommendations in this report.

APPENDIX A

Project Canary's major clients					
Date	**Company**	**What it does / where located**	**What is measured / monitored**	**Potential Conflict of Interest**	**Earthworks monitoring**
Nov 01, 2019	ARB Midstream	Operates one of largest independent networks of pipelines in Colorado.	Company says monitoring will "improve our operations and efficiency" and "help oil and gas industry sustain its social license to responsibly develop hydrocarbons."[246]		
Nov 22, 2019	Jonah Energy	Has assets in the Jonah Field in Sublette County, Wyoming	Received a Gold rating for its Wyoming assets[247]		
Jan 16, 2020	Crestone Peak Resources	Exploration and development of oil and gas reserves in Rocky Mountain Region	Plans an initial deployment of the Project Canary monitoring technology on well sites representing about 80 % of the company's production.[248]		Yes
Feb 24, 2020	Bayswater Exploration & Production	"A leading oil and gas producer with significant operations in Colorado"	"By mid-2020, Bayswater will install monitoring devices at locations encompassing approximately 99% of its production in Colorado's DJ Basin."[249][250]		Yes
Sept 21, 2020	Flywheel Energy	Operator of largest position in Fayetteville Shale.	Achieved TrustWell certification, including a Gold rating for Fayetteville Shale gas production operations[251][252]		
Jan 28, 2021	EQT	Gas company with operations in Marcellus and Utica Shales in Appalachian Basin.	EQT announced its commitment to a pilot project to demonstrate the production of RSG[253]		
April 13, 2021	Chesapeake Energy	Develops unconventional oil and natural gas assets in U.S.	A pilot partnership to produce certified RSG at well pads in Marcellus and Haynesville shales[254]		
April 19, 2021	Rio Grande LNG and NEXT Carbon Solutions	Developing Rio Grande LNG export facility in South Texas, which links Permian Basin and Eagle Ford Shale to global LNG market.	Joint pilot project for monitoring, reporting, and independent third-party measurement and certification of GHG intensity of LNG to be sold from LNG export facility in Port of Brownsville, Texas"[255]		
May 12, 2021	Xcel Energy	Power provider across eight Western and Midwestern states.	Xcel Energy says it will purchase certified low-emission intensity natural gas produced by Crestone Peak Resources for use in Colorado operations[256]		
May 25, 2021	PureWest	PureWest controls more than 126,000 gross (115,000 net) acres in Pinedale and Jonah Fields in Wyoming's Green River Basin.	Partnered with PC to certify Company's production as TrustWell RSG gas. PureWest and PC will also partner on a digital blockchain initiative.[257,258,259,260] November 2022: Company says it "Achieved one of the lowest methane intensity rates in the country .. Received Platinum Certified TrustWell™ Responsibly Sourced Gas (RSG) on 90 wells by Project Canary."[261]		
May 26, 2021	Berkshire Hathaway Energy	First large-horsepower fleet with CleanMachine technology for conventional compressor units	The CleanMachine received the first-ever equipment-specific TrustWell Responsibly Sourced Gas certification for midstream equipment.[262]		

June 23 2021	Southwestern Energy	One of largest gas producers in the U.S., holding 768,000 acres in the Appalachian Basin and 257,000 acres in the Haynesville Shale of Louisiana.	Seeking to certify its entire production base. Update: In Appalachia, Southwestern has 1,575 wells certified and just over 800 wells in the Haynesville shale play. The work will begin in July 2021 and will cover not only future wells but also current ones to an estimated 3bcf of gas production in Pennsylvania, West Virginia and Ohio. Its first basin-wide deal for PC. [263,264,265,266,267,268]		
July 2021	Great Western Petroleum (taken over by PDC)	Focused on Wattenberg Field in Colorado and Delaware Basin in West Texas[269]	Monitoring plan submitted for Raindance Pad, Weld County, Colorado		
Aug 02, 2021	Vine Energy	Focused on development of gas in Haynesville and Mid-Bossier shale in Haynesville Basin of NW Louisiana	An agreement with PC in which Vine is expected to become the first in Haynesville Basin to certify 100% of assets and gain access to certified, RSG markets.[270]		
Sept. 02, 2021	Seneca Resources	Explores and develops gas and oil reserves in California and Appalachian Region, including the Marcellus and Utica Shales.	Seeks RSG certification for approximately 300 million cubic feet per day of Appalachian production, covering nearly one-third of Company's natural gas production and also intends to install PC's monitoring devices at three well pad locations. In March 2022, Seneca announced it had achieved certification under TrustWell program, which covered 121 of Company's gas wells in Pennsylvania, representing approximately 30% of gas production[271,272,273]		
Sept 29, 2021	Tallgrass Energy Partners	Owns a 75% stake in Rockies Express Pipeline, which transports up to 4.4 bcfd of gas between northwestern Colorado and eastern Ohio.	Will begin monitoring emissions, including methane and other GHG, making it first U.S. company to measure and certify the environmental impact of operations on an interstate natural gas pipeline. Feb 2022: Entered an agreement with PC to develop a program for monitoring and sequestered carbon volume verification at its Eastern Wyoming Sequestration Hub project[274,275]		
Sept 29, 2021	Chisholm Energy Holdings	Has assets in Lea and Eddy counties, New Mexico, focussed on unconventional opportunities in northern Delaware Basin	"Partnership to install real-time air emissions monitoring devices on select production facilities in southeastern New Mexico"[276]		
Sept 30, 2021	Laredo Petroleum	Focussed on exploration and development in Permian Basin of West Texas.	Announced implementation of pilot project for monitoring of facilities in Howard County and initiating RSG certification for all wells in western Glasscock and Howard County. In May 2022, company achieved PC Gold certification for approximately 31,500 BOEPD of production to become first Permian producer to receive TrustWell™ RSG certification[277,278]		
Oct 13, 2021	Verdad Resouces	focused exclusively on horizontal development in the Denver-Julesburg Basin	As part of its Air Quality Monitoring Plan to Colorado, the company outlines how it is using PC sensors with its Timbro Pad.[279]		Yes
Dec 6 2021	Tug Hill And XcL	Principally operate in West Virginia's Marshall and Wetzel counties ... Tug Hill produces more than 800 Mmcf/d of natural gas	Seeking RSG certification for the entirety of upstream and midstream assets via PC. Partnership builds on Tug Hill's pilot program where company gained 'platinum certification' on 45 of the company's wells[280]	Yes	
Dec, 2021	Olympus Energy	Operations in southwestern Pennsylvania, reported nearly 160 MMcf/d of production in September	December: Partnered with PC: July: 100% of YE21 assets now RSG certified. Asset-level Platinum ratings[281,282,283]		
Dec 15, 2021	Tennessee Gas Pipeline Company	Owned by Kinder Morgan, which owns or operates approximately 83,000 miles of pipelines	Tennessee seeks regulatory approval for "RSG gas" from FERC, accredited by PC[284] [285,286]		

Jan 19, 2022	Civitas	Colorado's largest oil and gas producer.	To voluntarily plug 42 wells that were orphaned by previous operators located in and around Colorado, with Project Canary.[287]	Yes	
January 31, 2022	PennEnergy Resources	Focused on the development of shale resources in Appalachian Basin	Achieved PC's TrustWell® certification across its entire asset and earned highest ratings on 99% of its wells. Received PC's top "Gold" and "Platinum" ratings on 375 out of its 378 wells[288]		
Feb 7, 2022	Range Resources and Engie	Range is one of the largest gas producers in Marcellus Shale. Engie is one of the largest energy companies in the world, with a turnover in 2020 of 55.8 billion Euros.	PC will provide monitoring equipment to verify low methane emissions and RSG certification through its TrustWell® for Ranges operations in the Appalachian Basin. ENGIE Energy Marketing, market the RSG via its blockchain-based platform, The Energy Origin.[289]		
Feb 16, 2022	Antero Resources	Focused on the Marcellus and the Utica shales in the Appalachian Basin.	Received RSG certification following completion of PC Pilot[290,291]	Yes	
Feb 23, 2022	Chevron and its subsidiary, Noble	One of the world's leading oil and gas companies	Initially started a pilot project to certify operational and environmental performance in U.S. upstream, including in the Permian Basin of Texas and DJ Basin of Colorado, deploying Canary X monitors. June Update: Upstream assets earned PC's highest ratings, 82 wells achieved "Platinum" status and 3 wells received "Gold" status[292,293]		Yes
Feb 25, 2022	DT Midstream	Connects Midwestern, Eastern Canada, Northeastern and Gulf Coast regions to Haynesville and Marcellus/Utica shale in Gulf Coast and Appalachian Basins	Announces new partnership with PC to monitor methane emissions.[294]		
March 3, 2022	BKV Corp and BKV Power	Assets in the northeast Marcellus Shale, Pennsylvania and in Barnett Shale, North Texas, 17th top gas producer in the U.S.	Entered into arrangements with PC to address GHG emissions with intent to deliver RSG to Temple I power plant. Installing monitoring additional units in Marcellus and Barnett Shale throughout 2022 and into 2023.[295,296]		
March 10, 2022	Ascent	One of the largest independent producers of gas in U.S., operating in Utica Shale in southern Ohio	Certified first RSG in January 2022 through our pilot program with PC and received their Platinum certification for 2022[297]		
April 27, 2022	Rockcliff Energy	An exploration and production company focused on the Haynesville play in East Texas	Has deployed 171 Canary X monitors on 57 sites, representing 95% of the company's ~1.5 bcfd production. May update: 143 wells in Haynesville shale play have been assessed and certified by TrustWell - remaining will be assessed by the end of June 2022.[298,299]	Yes	
Aug 24 2022	Kellas Midstream	BlackRock and GIC backed - responsible for transporting 40 % of U.K.'s domestic gas production	Announced it has deployed emissions monitoring at its Teesside Central Area Transmission System[300]		
Nov 3, 2022	Tourmaline Oil Corp	Canada's largest natural gas producer	Received preliminary platinum ratings from PC or Trustwell assessment on our Northeast BC assets, and score ranks in top 10% in North America[301]		
Nov 11, 2022	ENGIE Energy Marketing and BKV Corporation	Engie is one of Europe's largest multinational energy companies	Developing a framework and marketing program to develop a market on Carbon Credits associated with measured Carbon Sequestration[302]		
January 19, 2023	POCO	Privately held company with operations in the Denver-Julesburg Basin	Announces it has received Platinum rating for 100% of its 22 operated horizontal wells in Colorado.[303]		

APPENDIX B

Site Name (Green indicates sites included in case study section)	Date	OGI Pollution?	CEM detection?	Monitor Used
Bayswater Almont-Dotsero Monitoring Plan	8/29/22	Y	N	Canary-S
	11/12/22	Y	N	
Bayswater Blehm Monitoring Plan	9/28/22	Y	N	Canary-S
	11/12/22	Y	N	
Bayswater Ruby Monitoring Plan	8/31/22	Y	N	Canary-S
	9/28/22	Y	N	
Bayswater Topaz Monitoring Plan	7/28/22	Y	N	Canary-S
Crestone Eastern Hills Monitoring Plan	10/26/22	Y	N	Canary-S
	11/11/22	Y	N	
Crestone Grande Monitoring Plan	5/22/22	Y	N	Canary-S
Crestone Warner Monitoring Plan	8/30/22	Y	N	Canary-S
	11/13/22	Y	N	
Noble DP Guttersen C28 Monitoring Plan	8/30/22	Y	N	Canary-S
Verdad Timbro 1717 Monitoring Plan	8/29/22	Y	N	Canary-S
Extraction Interchange A	5/9/22	Y	N	Aeroqual AQS-1
Extraction Interchange B	6/28/22	Y	N	Aeroqual AQS-1
PDC Energy Volt	8/30/22	Y	N	SENSE-IT
Kerr McGee Schrute Farms Monitoring Plan	8/29/22	Y	N	SENSE-IT
	10/25/22	Y	N	SENSE-IT
Kerr McGee Paul Nelson Monitoring Plan	10/25/22	Y	N	SENSE-IT
	11/14/22	Y	N	SENSE-IT
Confluence Bigfoot Monitoring Plan	8/30/22	Y	N	SGS SMART SENSE

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