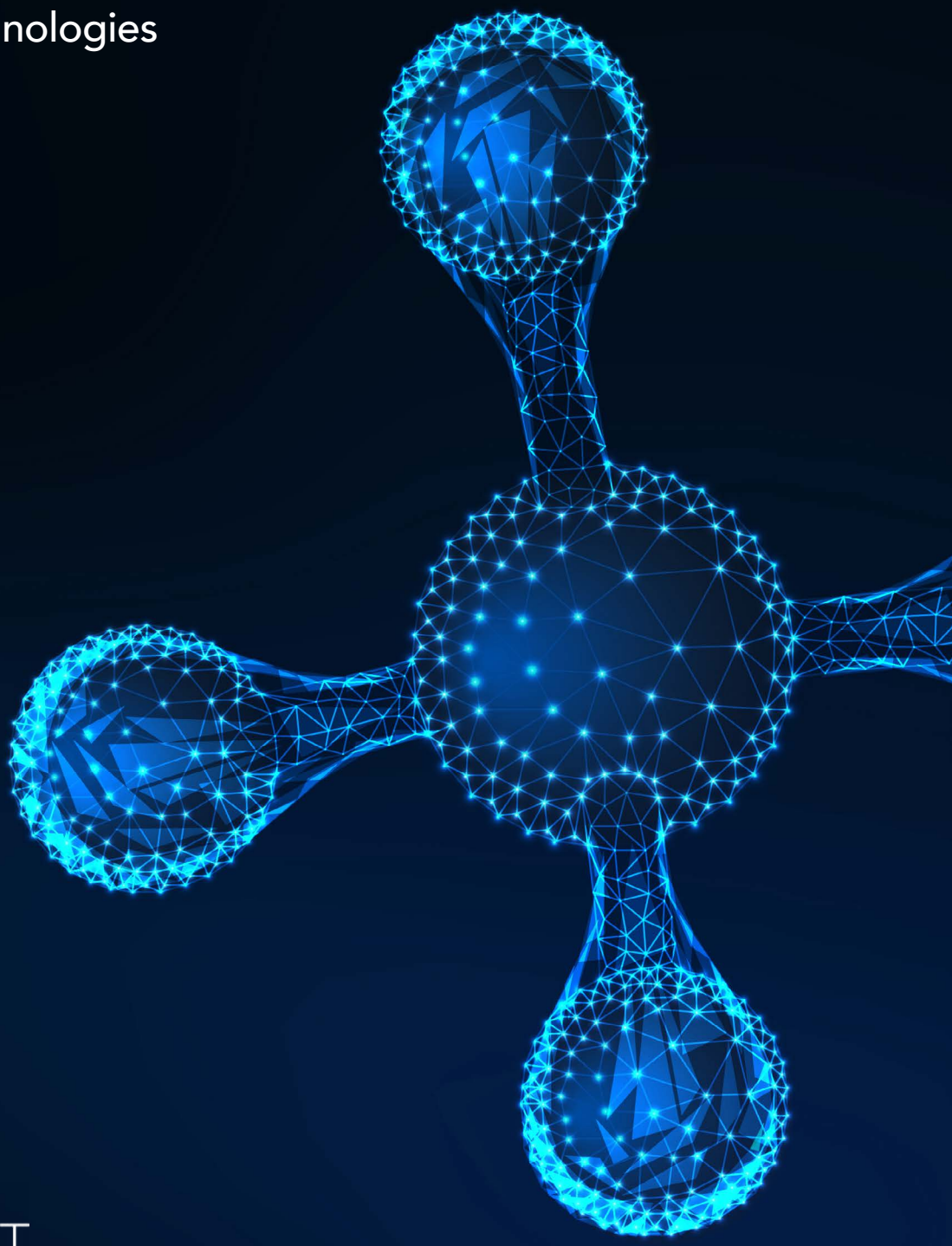
EXECUTIVE SUMMARY

MARCH 2022

METHANE QUANTIFICATION: TOWARD DIFFERENTIATED GAS

An Assessment of Methane Measurement and Monitoring Technologies



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Introduction

The Problem: Accelerating Risk for Natural Gas

The August 2021 report by the UN Intergovernmental Panel on Climate Change (IPCC) included many dire warnings regarding global temperature rise and new policy and actions that should be taken; however, one recommendation that garnered some of the most significant attention was the panel's urgent call for action on methane emissions. The panel identified methane emissions as a fundamental driver of climate change, representing the first time a major climate report has recognized the need to address methane emissions as part of the pathway to limiting global warming.

It has become clear that risk for natural gas is accelerating. Nonetheless, with emerging technologies, the oil and gas industry has an opportunity to reimagine the future of natural gas in ways that promote transparency, trust, and transactability in differentiated gas markets.

The Vision: Transparency, Trust, Transactability

The current environment has created a compelling leadership opportunity for the oil and gas sector to get ahead of regulator and investor expectations on methane emissions through quantification and reduction. A small number of companies are already pursuing this opportunity by adopting three principles for methane emissions measurement, monitoring, reporting, and verification, namely: Transparency, Trust, and Transactability.

Transparency begins with a recognition that companies must go beyond leak detection and repair to quantification of methane emissions. This will necessarily involve making accurate, granular measurements and frequent monitoring. To achieve transparency of methane emissions, companies will need to understand the measurement capabilities of various technologies; pilot and deploy technologies to measure emissions; and create a baseline emissions measurement against which to compare future reductions.

Trust involves ensuring that regulators, investors, and other stakeholders have confidence in emissions data and can rely on such data to make policy and investment decisions. This will require verification of emissions data not just by industry or environmental NGOs, but by independent third parties or data platforms. To achieve trust, companies can identify and work with third parties to validate emissions measurements. In addition, all stakeholders will need to come to consensus about standard baseline emissions measurement methodologies (which in the near term could be a "hybrid" of measurements and emissions factors as proposed by the GTI Veritas program) and standards for reporting baseline emissions and regular updates.

Transactability means that customers can buy and sell products based on emissions data, ultimately creating new markets for differentiated gas products. This will require that data is interoperable across multiple systems and the development of standard, secure certification processes for products.

Development of a framework that promotes strong performance metrics for all segments of the gas supply chain and a market for differentiated natural gas must connect the dots between transparency, trust, and transactability. A strong and robust future for natural gas will require high quality data and rigorous MRV to gain credibility in the eyes of NGOs and policymakers. In addition, it will require the integration of methane emissions data with financial performance data that can help provide the currently missing link between ESG reporting and data-driven climate accounting.

We have an opportunity to ensure a strong future for natural gas with real emissions reductions, consumer trust, and new markets for differentiated products. This assessment addresses a critical piece of achieving this future.

How Do We Get There?

Experts have noted that there are at least 600,000 methane leaks in the U.S. today, and even this large number may represent an undercount.[1] Up until recently, most companies have focused on leak detection and repair (LDAR)—an undoubtedly worthy goal, but not one that results in a full picture of a site's emissions.

Quantifying emissions is challenging because there are so many potential point sources—myriad facilities, equipment, and small components of equipment at each site. How can companies measure these potential sources in an accurate, timely, and cost-effective way?

Traditional approaches for LDAR have typically involved optical gas imaging (OGI) cameras that provide a visual of methane leaks at various resolutions and distances. However, the shift from LDAR to measurement will require more sophisticated sensors that do not only detect, but also quantify methane emissions.

Sensor technologies have expanded rapidly in recent years and promise to enable increasingly cost-effective methane solutions. Sensors are generally mounted or integrated with other technologies, and these technologies each have strengths and limitations for measuring methane emissions.

Scope of this Tech Assessment

This assessment reviews leading and emerging technologies that are being deployed with sensors for methane measurement and monitoring, specifically:

1. The measurement capabilities of various technology categories;
2. How specific technologies have been piloted or deployed in the field; and
3. Leading technology initiatives that have integrated multiple technologies, and in some cases, implemented approaches for independent verification of emissions and certification of differentiated gas.

This assessment will describe six technology categories and more than 30 detailed profiles of leading methane emissions technologies.

This assessment also highlights "Technologies in Action"— leading technology initiatives where multiple stakeholders have collaborated to integrate multiple measurement and monitoring technologies in the field and validate the resulting data for use in reporting and certification.

[1] Cate Haight, "The Fight Against Methane," *Columbia Energy Exchange podcast*, July 13, 2021, https://www.energypolicy.columbia.edu/fight-against-methane.

Key Takeaways from Preliminary Ratings (Version 1.0)

COEFFICIENT developed a set of preliminary ratings of the technologies profiled in this report. These ratings are based on the information we have been able to collect and our evaluations of how well each technology addresses the 3Ts criteria; they are intended to help inform stakeholders about the general strengths and limitations of various technologies in a policy context and indicate how different technologies can complement each other. We believe any of the technologies profiled and rated have the potential to be valuable solutions for different contexts; the intention of the ratings is not to provide a full technical evaluation of the specifics of each technology or to exclude any technology from consideration as a methane measurement solution, but to start a dialogue about the potential of these technologies to work collectively to provide a more transparent, trustworthy and transactable energy future.

Ratings were assessed on a 1-5 scale, with 1 being the lowest and 5 being the highest. Ratings were assigned based on known information; where not enough publicly available information was found on specific criteria, no rating was made. All but three of the profiles were rated on at least ten criteria, and most were rated on between 11 and 13 criteria. New or additional information about any technology may impact the rating. Ratings are likely to evolve as additional information becomes available in future phases of this project.

The following are key conclusions from these preliminary ratings:

- Almost all companies/technologies have the *capability* to quantify methane emissions and integrate with Digital MRV systems. However, our sense is that the technologies are *not actually implemented* in this way by most oil and gas operators; instead, many operators are focused on regulatory compliance under EPA OOOOa rather than taking the next steps toward measurement and quantification.
- Most companies/technologies are offered as a product or service to customers, and except for some satellite technologies, the data collected is housed in proprietary systems and not made public. Without new standards, this may create interoperability barriers to wider deployment and integration with new regulation.
- Timeliness (how quickly data is available) is a strength of most companies/technologies; most offer access to data in real time or near real time.
- Very few companies/technologies are focused on key criteria for trust and transactability, specifically: verification activities; integration with emerging policy and regulation; certification activities; or investor activities. As such, most profiles receive ratings of 1 on these criteria.
- Many companies/technologies received a rating of 3 on maturity/scale, indicating that they are currently or have been piloted in the field with oil and gas operators, but testing and improvements are ongoing, and the technologies may not yet be ready for wide-scale commercial deployment.
- The overall top-rated profiles are: MethaneSAT (satellite); TROPOMI (satellite); Picarro (mobile- other/cross-cutting); Baker Hughes LUMEN Terrain (stationary); and Project Canary (stationary). These generally received higher ratings not necessarily because of better technical specifications but rather because they were some of the very few companies/technologies that are addressing verification and certification activities. Each of these received an overall rating between 3 and 4. All other profiles received overall ratings between 2 and 3. The average rating across all profiles was 2.43.
- For additional details regarding how ratings were defined and calculated in this report, and for recommendations on how to evolve these criteria in future phases of this project, please contact COEFFICIENT.

Conclusions and Recommendations

The following are key conclusions from this assessment and recommendations for industry and policymakers.

- Many oil and gas operators today have not yet moved from a mindset of leak detection to a **mindset of measurement and quantification**. In large part, this is because regulation has not required them to do so. However, as measurement technologies continue to improve and mature, both investors and regulators are likely to demand more on measurement and quantification. There is an opportunity for industry to get ahead of this trend by moving toward measurement and quantification now.
- Very few companies/technologies profiled in this assessment are focused on key criteria for **trust and transactability**, specifically: verification activities; integration with emerging policy and regulation; certification activities; or investor activities. These criteria are absolutely critical to addressing growing pressure from investors and to building markets for Responsibly Sourced Gas (RSG).
- Measurement and monitoring **technologies have advanced significantly** in recent years and will likely continue to evolve as industry and other stakeholders learn more about their performance in the field under various scenarios and conditions. Industry and its partners should **engage directly with policymakers to share data and outcomes** that can help inform and ensure effective policy and regulation.
- Policymakers and regulators have an opportunity to enable more **transparent methane emissions reporting** and ensure **real emissions reductions** in the near term and long term by using this assessment and other resources to understand the strengths and limitations of advanced measurement and monitoring technologies and how these technologies are being demonstrated and assessed in the field. Policymakers should consider **establishing protocols for assessing the performance** of emerging measurement and monitoring technologies to better ensure their effective deployment.
- Policymakers and regulators will also need to better understand how data collected using these technologies can be used to **calculate a company's total emissions**. Efforts are underway by the Gas Technology Institute and others to **develop methodologies** for integrating and reconciling top-down and bottom-up measurements of methane emissions, and policymakers should also consider a government role in establishing or verifying such methodologies.
- Companies should consider the formation of a **buyer's consortium** for customers interested in RSG procurement. Such a consortium could help support policymaker outreach and education and accelerate the deployment of measurement and verification technologies necessary to certify RSG and enable new markets.