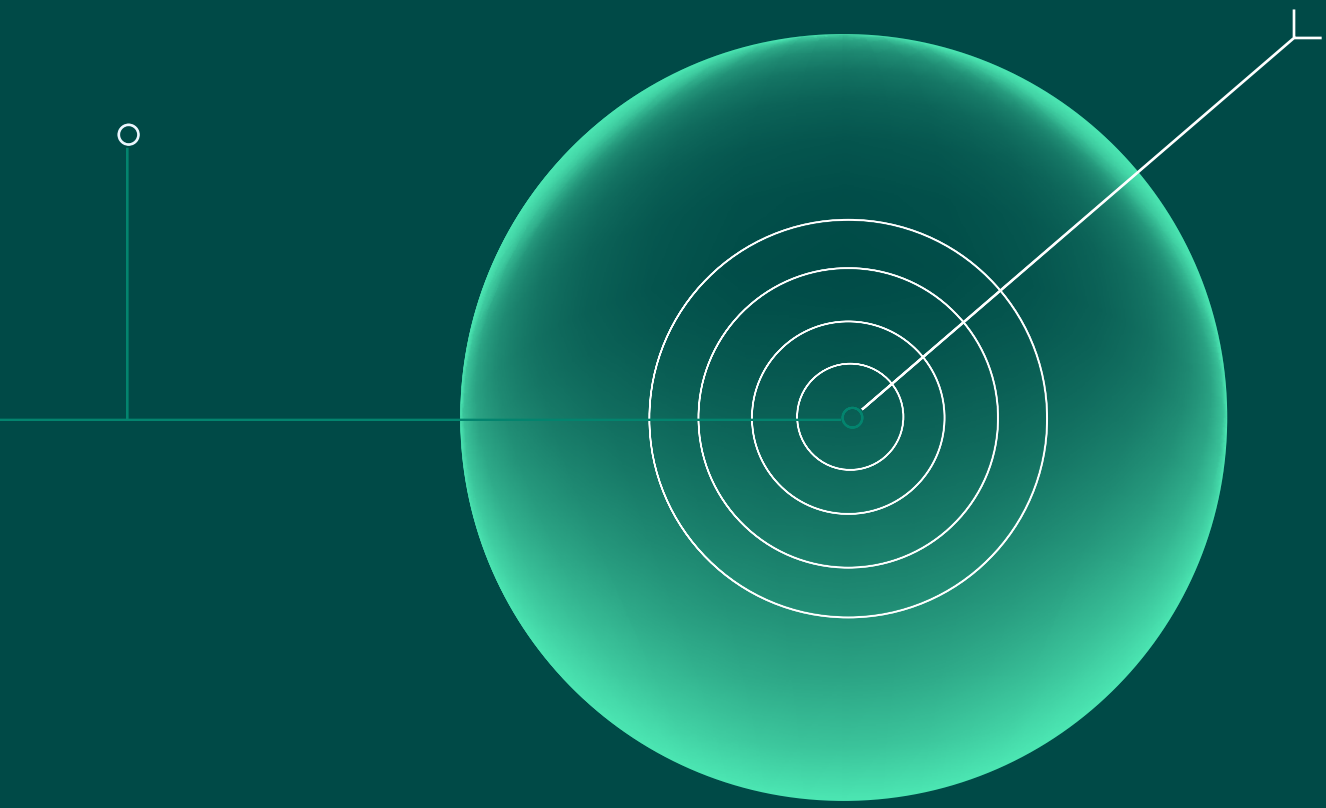
Hitting the Mark: Improving the Credibility of Industry Methane Data



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Foreword

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From Hong Kong to Houston, we have a problem. Greenhouse gas emissions are at an all-time high, when they should be fast moving towards zero. As one of the world's 15 largest investors, addressing the climate emergency is a priority for us and for our clients; the work of thought leaders such as Environmental Defense Fund continues to be instrumental in shining a spotlight on this risk.

Reaching net zero emissions will require significant changes across the entire global economy, yet some of the greatest challenges lie in the oil and gas sector. There is no doubt that oil and gas have a role to play in the energy transition. But whether it is a starring or supporting role will in large part depend on the industry's approach to methane. Currently, an estimated 2% of the world's produced gas is being lost to the atmosphere as methane, a greenhouse gas that is over 80 times more potent than carbon dioxide over a 20-year timespan. This makes neither climate, nor business sense. Yet there are immediate opportunities: for an estimated half of the world's methane emissions, capturing and selling the gas could be worth more than the tech upgrades involved.

So where should companies start? As ever, with the numbers. This report outlines an important new approach to measuring and reporting methane emissions. Currently, there are challenges to methane data availability and accuracy, with status quo methods often underestimating the reality of potent emissions into the atmosphere. As investors, we place great value upon the continuous journey of data integrity. Our expectations around the quality of companies' climate disclosures are thus evolving fast, in many cases going well beyond compliance with government mandated reporting. From satellites and sensors to drones and AI, companies should draw on the latest advances in science and monitoring technology to present a more accurate picture of their business impacts.

We believe that strong oversight of a company's operations correlates with good management and, therefore, with success in the future. For us, this is about financial materiality and core corporate strategy – about risk management, not "corporate social responsibility". Indeed, from savers to pension schemes, an ever-growing number of our clients are interested in the climate impact of their investments, looking for reassurance that the energy companies they invest in will at least survive, or even become an active part of the solution.

The extractive industry treats zero accidents as the only acceptable target. Zero tolerance for methane emissions should similarly become the norm. And we are seeing signs of progress, with a growing number of companies aiming for zero emissions - from their rigs through to the end consumer – even linking these targets to executive and employee pay. Although

Foreword

headline commitments are key to setting strategy, we know the hard work lies in the less glamorous, but just as important step of implementing and measuring progress through the necessary processes and data systems. This innovative report provides companies with a roadmap to go from telling what they will do to credibly showing what they have done. Giving investors a toolkit to better differentiate between the leaders and laggards. We can then take action by voting at investee companies.

Our challenge is clear: industry leaders have an opportunity and an obligation to keep raising the bar, while all other companies should aim to catch up. As a significant investor in the energy sector, we will continue to work with companies and stakeholders like EDF to drive the adoption of best practices in the industry and advance essential policies and regulations.

This innovative report provides companies with a roadmap to go from telling what they will do to credibly showing what they have done. It gives investors a toolkit to better differentiate between the leaders and laggards.

LGIM is the investment management arm of Legal & General Group, with assets under management of $1.4 trillion (as at 30 June 2019, including assets managed by LGIM in the UK, LGIMA in the US and LGIM Asia in Hong Kong. The AUM includes the value of securities and derivatives positions).

Executive Summary

Methane emissions are a challenge to the global oil and gas industry and the role and reputation of natural gas in a decarbonizing world. Credibly demonstrating near-zero methane emissions is both an imperative for the industry writ large, and a competitive differentiator for companies in the early phases of the energy transition.

Leading companies and coalitions are taking steps to address this challenge, including commitments to time-bound, quantitative methane targets, and implementation of best-management practices and innovative technologies to achieve reductions. While these initial steps are necessary, the fundamental question persists: Will industry leaders prove that they are making sufficient progress on reducing methane emissions? The answer to this question relies heavily on the quality of industry's data and the level of public trust in it.

Today, the oil and gas industry has a methane-emissions data problem. The majority of emissions data is derived from desktop calculations informed by engineering equations, not real-world measurements. This has significant consequences. Around the world, research reveals that methane-emission inventories consistently underestimate, and in some cases overestimate, real emissions. For example, a paper published in Science by experts from more than a dozen research institutions, including Environmental Defense Fund, found that methane emissions associated with U.S. oil and gas production are 60% higher than EPA estimates, which are derived from calculations.

Improving the accuracy of emission estimates is necessary to instill confidence that progress is being made. Encouragingly, advances in methane detection and quantification technology can support robust methane measurements across varying spatial and temporal scales.

While the journey begins with increased and improved data acquisition, it does not end there. This paper explores three critical actions that executives must champion to improve data accuracy and earn stakeholder confidence that methane commitments are real.

1. Integrate direct measurement into emissions estimates. All companies with methane targets must ramp up field measurement to bolster emission inventories with actual emissions data. Specifically, companies seeking to accurately quantify methane emissions should conduct bottom-up measurements and integrate these findings with top-down, site-level methane emissions measurements taken from a statistically representative sample of facilities.

2. Increase the transparency and granularity of methane emissions reporting. Despite incremental progress, industry reporting on methane management and performance often still falls short of external stakeholder needs. As companies increase measurements to inform emissions reporting, the soundness of methods, the care with which they are applied, and the accuracy of the data they produce, are essential to earning credibility with external stakeholders. Additional information such as the methods applied for measurement and sampling plan design, emissions inventories broken out by region, country and/or basin, and the summary findings from third-party audits all contribute to the trustworthiness of methane disclosure.

3. Validate reported methane data through a qualified and independent third-party audit. Companies that report emissions data should take additional steps to ensure the validity and credibility of information, particularly as public trust in the oil and gas industry continues to strain. External auditing by an established, independent firm can add value and improve public confidence in emissions disclosure. As the methane-auditing space matures, third-party auditors will need the technical expertise to rigorously assess both the accuracy and integrity of the data as well as the quality of the methods.

The first half of this new decade are defining years in which oil and gas companies must prove to investors, civil society, and governments that they are materially reducing their methane emissions. This paper provides recommendations and considerations for companies and coalitions as they work to demonstrate progress amidst the climate crisis.

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Introduction

As the climate crisis deepens, business and government leaders increasingly recognize the urgent need to transform the energy system on a pathway to net-zero carbon emissions by mid-century. A critical and immediate step on any credible pathway is to dramatically reduce methane emissions from the oil and gas sector. While governments have the responsibility to enact policies and regulations that drive emissions reductions, industry bears the responsibility — and has the opportunity — to take concrete action and demonstrate rapid progress.

The first half of this new decade will determine if industry is up to the task. Industry groups like the Oil and Gas Climate Initiative (OGCI) and One Future have publicly committed to reach stringent, quantitative targets for methane emission intensity performance by 2025. Many operators have set their own reduction targets, with more likely to follow, as investors, governments and the public demand action. The question now is simple: Will industry leaders prove that they are making progress on reducing methane emissions against the targets they themselves have set?

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Acquiring and reporting high-quality data is indispensable for earning credibility on any Environmental, Social, Governance (ESG) criteria, and is particularly important in methane emissions management. An invisible and odorless gas that can be emitted at various points and times from the oil and gas supply chain, methane presents challenges for monitoring and measurement. Encouragingly, innovation — from methane-quantifying satellites to drone-mounted sensors, to stationary, continuous monitors — is unleashing a new era of higher-quality, comprehensive emissions data. Now is the time to embark on a strategic transition from "analog" to measurement-based methods of estimating methane emissions.

The purpose of this paper is to:

- Establish the direction for a new, direct measurement-informed approach for estimating and validating methane emissions.
- Galvanize an action-oriented dialogue among leaders and experts about how such approaches can be quickly realized at cost-effective scale.
- Provide guidance and considerations for companies and coalitions as they pursue credible, accurate measurements.

These improvements have the potential to increase the accuracy, precision and credibility of emissions data, while earning the confidence of investors, non-governmental organizations, governments, and the public in methane emissions management efforts. We urge business leaders to invest in the people and the process to make good on their methane emissions commitments by striving for robust, accurate, and transparent data that can verify strong emissions performance.

Environmental Defense Fund invites and encourages constructive discussion and accelerated action on this essential facet of the methane challenge in the months to come.

Part 1: An approach to enhance emissions estimation

Key Recommendations

- Incorporate emissions estimates based on methods using direct measurement across varying spatial scales.
- Conduct methane measurements on a statistically-representative sample of facilities to inform corporate-level methane emissions inventories.
- Integrate top-down and bottom-up measurement data to validate emissions inventories and enhance methane mitigation strategies.

The terms “bottom-up” and “top-down” do not have a standard definition and are often used inconsistently. Typically, “bottom-up” refers to the traditional emission inventory approach that relies primarily on component-level emission factors and engineering equations, while “top-down” refers to the use of atmospheric measurements to estimate emissions at larger spatial scales. However, this distinction is not always clear since both approaches can utilize emission factors and/or atmospheric measurements. For example, component-level emission factors can be based on measurements of methane concentration near the leak. Meanwhile, downwind atmospheric measurements of sites can inform site-level emission factors. For this report, we distinguish between bottom-up and top-down based on the spatial scale of emission estimates. We define “bottom-up” as an approach that estimates emissions at the component-level, such as a connector or pneumatic controller. We define “top-down” as an approach that estimates emissions at a larger spatial scale than component, ranging from facility-level to large geographic areas like a basin. In both top-down and bottom-up approaches, direct measurement is critical to the integrity and accuracy of the outputs.

While we advocate in this paper for the increased use of top-down data to estimate emissions, we do not recommend that companies no longer collect component-level, bottom-up data. As we explore, bottom-up methods have limitations that make them unsuitable as the sole data input for accurately estimating total emissions. However, component-level measurements remain valuable for understanding the sources of emissions, guiding mitigation, and reconciling total emissions. A holistic approach with complementary methods offers the greatest promise.

Traditionally, methane emissions from upstream oil and gas operations have been estimated using bottom-up emission factor approaches herein referred to as Bottom Up Emission Factors or

(BUEFs) such as generalized and static equipment and component-level emission factors and engineering equations. These approaches are currently standard practice for both voluntary emissions reporting and regulatory compliance in many jurisdictions around the world. For example, the EPA uses BUEF methods for their annual greenhouse gas inventory and requires companies to use this approach for submissions to the EPA Greenhouse Gas Reporting Program.

FIGURE 1. GENERAL EMISSIONS ESTIMATION EQUATION FORMULA

The general equation for emission estimation is:	where:
$$E = A \times EF \times (1-ER/100)$$	E = emissions A - activity rate EF = emission factor ER = overall emission reduction efficiency, %

SOURCE: Environmental Protection Agency 2014 National Emissions Inventory Report.

Over the last several years, advances have been made in atmospheric methane measurement techniques — herein referred to as “top-down” approaches. Atmospheric techniques measure concentrations of methane emissions from a variety of distances away from a source – from on-site devices such as drones that measure emissions from equipment groups to satellites that remotely quantify methane emissions over a large geographic region. From these measurements, total emissions for a defined area can then be calculated based on knowledge of how methane disperses in the atmosphere. Measurements of total methane emissions using top-down approaches can be significantly higher than aggregated, component-level emissions estimates calculated with emission factor-derived, bottom-up methods.

Top-down approaches have some limitations, particularly related to the relatively short duration of individual measurements. Since emission rates can vary widely across time and space, it is critical that top-down measurements are temporally and conditionally representative when they are used to extrapolate emissions across a wider area or time frame.

Throughout this paper, we consider top-down site-level measurements as the overall emissions for a specific site, inclusive of all possible emitting components and equipment, to be most accurately quantified using atmospheric measurements.

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Bottom-up emission factor-based approaches

Bottom-up, emission factor BUEF approaches, which traditionally rely on desktop equations instead of measurement for estimating methane emissions, have limitations that are well-documented and pose a material risk to the accuracy and reliability of reported methane emissions data.[1] Companies can address some of these gaps by integrating measurement-based approaches across spatial scales to enhance the credibility of reported emissions and validate progress against methane reduction commitments.

Studies in the U.S. and internationally have consistently found that inventories developed with BUEFs can significantly underestimate methane emissions.[2] For example, a paper published in *Science* by experts from more than a dozen different research institutions including EDF found that methane emissions associated with U.S. oil and gas production are 60% higher than EPA estimates based on BUEFs. This discrepancy is largely attributed to the limitations of BUEFs to incorporate emissions from less-frequent, high-emitting sources and other intermittent stochastic releases. Additionally, a meta-analysis of approximately 15,000 measurements from 18 peer-reviewed studies found that 5% of sources accounted for 50% of total emissions across a range of equipment and facility types.[3] To the extent that BUEFs do not include these high-emitting events, current methane estimates are likely to significantly underestimate actual, absolute emissions.

While the accuracy of BUEFs can be improved by increasing the size and representativeness of the underlying measurements used to develop emission factors, there are challenges to sufficiently eliminating the approach's bias towards underestimation. First, it is difficult to identify every piece of emitting equipment when collecting measurement data for the development of emission factors. Second, contemporary approaches for directly quantifying emissions at the component — or equipment-level — such as high-flow dilution sampling, have technical limitations that can make quantification of higher flow rates unsafe or inaccurate. Finally, existing modeling tools, such as the EPA-approved E&P Tank Model, are often inaccurate under anomalous system conditions. For example, an oil tank may emit orders-of-magnitude higher emissions than predicted from a static engineering equation if an upstream separator malfunction causes produced gas to vent out of the tank. While BUEF methods based on default emission factors and engineering equations remain valuable for developing preliminary emission estimates, particularly for sources with no recent measurement data, they should be replaced with more representative empirical data. This could include step-change improvements such as updating emission factors based on new measurement data that fully accounts for anomalous emissions.

[1] See Environ. Sci. Technol. 2015, 49, 5, 3252-3261 and Environ. Sci. Technol. 2015, 49, 8, 5161-5169

[2] See Science. 2018, 361, 6398, 186-188; PNAS. 2015, 112, 51, 15597-15602; Geophysical Research Letters. 2019, 46, 22, 13564-13573; Environ Sci. Technol. 2017, 51, 21, 13008-13017.

[3] Adam R. Brandt, Garvin A. Heath, and Daniel Cooley. Environmental Science & Technology 2016 50 (22), 12512-12520.

While bottom-up emission factors, BUEFs derived from traditional desktop calculations, can play a role in helping companies start to understand the general distribution of emissions across certain equipment types — and support the design of methane mitigation strategies — they alone cannot deliver comprehensive, accurate estimates of methane emissions required to credibly report on target progress and garner investor and public trust. As a result, companies need to move beyond a reliance on traditional factor-based methods for accurately estimating emissions. Reliable reports of total emissions must incorporate empirical data captured using both bottom-up and top-down measurement methods across a representative subset of sites.

Top-down approaches

Advances in atmospheric top-down measurement techniques enable methane emissions quantification at various temporal and spatial scales, ranging from sub-site to basin. Compared to bottom-up approaches that detect and measure emissions at the component or equipment-level, top-down approaches quantify total emissions by measuring all the plume(s) in a target area, reducing the likelihood that high-emitting sources are missed during the time of the survey. Top-down approaches are most effective at detecting emissions when they are deployed frequently, particularly for stochastic events that cause intermittent, high emission rates. Numerous platforms can be used for atmospheric measurements, including stationary monitors, ground vehicles, unmanned aerial vehicles (drones), aircraft, and satellites. These approaches vary in their ability to resolve emissions at different temporal and spatial scales due to significant differences in their detection limit, sensitivity and deployment frequency. For example, smaller, agile platforms such as drones may be able to quantify emissions from a single site or cluster of equipment by sampling local emissions plumes. In contrast, satellites often have coarser resolution – measuring methane concentration through the atmosphere, coupling that data with meteorological information, and estimating total emissions over numerous square kilometers. Given the diversity in operating profiles – from the small wellpads of onshore U.S., to the mega-facilities in the Middle East, to the complex offshore platforms in the North Sea – certain technologies will be better suited to specific environments.

There are three established, general approaches for quantifying site-level methane emissions, each of which includes several methods that have been tested by industry, academic researchers and published in peer-reviewed scientific papers:

- Mass balance approaches measure methane concentration upwind and downwind of a site or cluster of sites, typically with fixed-wing aircraft, and couple this data with wind speed and other meteorological information to estimate total emissions from the area between the upwind and downwind transects.

- Inverse dispersion modeling measures methane concentration downwind of a site and then calculates site-level emissions based on the estimated plume shape and magnitude, wind data, and assumptions about atmospheric transport, such as Gaussian dispersion. EPA's Other Test Method 33a is a commonly deployed inverse dispersion modeling approach that involves parking a research vehicle several hundred feet downwind of a site for 15 – 30 minutes. Similar approaches have been conducted with drones, which may use their enhanced maneuverability to distinguish and quantify plumes from individual pieces or groups of equipment.

- Remote sensing visualizes methane plumes by measuring total column methane concentrations between the ground and an aircraft, drone or satellite instrument. Remote sensing data can be analyzed with techniques similar to the mass balance or dispersion model methods to quantify emissions. The resolution of remote sensing technologies varies significantly. Several aircraft-based approaches can quantify emissions at the individual site level. Meanwhile, existing satellites typically have coarser resolution and may be constrained to extremely large emissions sources with well understood, complementary meteorological data.

Spotlight: Hitting the mark with the Oil and Gas Methane Partnership

The CCAC Oil & Gas Methane Partnership (OGMP) was launched at the UN Secretary General's Climate Summit in New York in September 2014. The initiative currently has eleven partner companies, including both International and National Oil Companies. In 2019, a thorough redesign was conducted - substantially redefining the level of ambition.

Starting in 2020, OGMP member companies intend to embark on the adoption of an approach similar to that proposed in this paper. In the revised framework, companies will commit to start reporting consistently using direct-measurement informed methods across all operated, as well as non-operated, assets.

OGMP includes five levels of reporting, through which member companies announce their targets and report emissions, as well as their progress in reducing reporting uncertainty.

The inclusion of non-operated joint ventures in the framework will increase the reach of the program. The inclusion of those emissions will provide the public greater insight into the environmental footprint of the industry and allow governments to better target reduction efforts along the entire value chain.

Finally, a new institution hosted in The United Nations Environment Programme (UNEP) is expected to issue a report disclosing each company's aggregate emissions. It will also provide a view on the state of global oil and gas methane emissions, correlating company reports with satellite data, national inventories and science studies.

Considerations when designing a measurement campaign

Oil and gas companies seeking to accurately quantify their methane emissions should conduct bottom-up measurements and integrate these findings with top-down, site-level methane emissions measurements to derive corporate inventories. This approach is well-documented in numerous peer-reviewed studies, including Alvarez et al 2018, which synthesized data from over 400 site-level measurements to estimate U.S. oil and gas methane emissions.

There are three fundamental steps to consider when designing an accurate, unbiased measurement-based methane emissions inventory: site selection, sample size definition, and continuous improvement.

Select representative, unbiased sites for measurement.

It is critical that site selection for measurements avoids bias, which can lead to non-representative data. Additionally, it is essential that the sample of sites selected are verifiably representative of the population of assets. For example, if a vehicle is used to survey roads for methane plumes and then only quantifies sites with detected plumes, emissions data will be biased high because sampling omits sites below the survey detection limit. Conversely, emissions data will be biased low if measurements include only well-functioning sites, excluding those with anomalous conditions. Representative sampling considers all sites for potential measurement and is kept unbiased by making measurements as randomly as possible, though stratified random sampling approaches can help to increase accuracy while reducing cost.

For companies with relatively homogenous assets, such as a standard pad or facility design in one region, non-stratified random sampling may be sufficient to deliver the average site-level emission rate if no parameters have a statistically significant effect on emission rates. However, most companies have diverse assets such as both onshore and offshore sites or wells across multiple basins with a wide range of production rates, site designs, and other characteristics that impact site-level emission rates. For companies with more diverse assets, stratified measurement plans guided by statistics will be necessary to obtain representative measurement data from a select subset of assets. As a company assesses its portfolio to develop a sampling plan, it can divide the population of its assets into like groups with shared attributes, thus building a stratified sample. For example, different asset types — such as production facilities and processing plants — should be measured separately since variable throughput and on-site equipment can result in divergent average emission rates. Sites of the same asset types may be advantageously divided into like-groups using quantitative parameters, such as gas production, which can potentially affect emissions.

When selecting sites for an unbiased measurement plan, companies should examine other existing data, such as operations information, to determine if there are clear patterns that can inform the division of assets into like-groups/categories. If assets are diverse but data are lacking patterns, companies may start by collecting broad, preliminary data – including that already collected from bottom-up inventories – to assess possible options for categories of sites before commencing a full measurement study.

◯ Determine the optimal sample size and manage uncertainty.

The optimal sample size for a measurement program is determined by the total number of sites and variation within the population. In general, the larger the sample size and the higher the frequency of measurements, the smaller the uncertainty of the results within a category of sites.

With limited measurements, it is more likely that a few measurements at the extreme ends of the distribution will cause the average to deviate. Emission rate distributions typically have a highly positive skew, which results in a relatively small number of high emitting sites accounting for the majority of emissions. As a consequence, estimates based on a limited sample of measurements can bias low, since they likely exclude these highest emitting sites. The most effective approach to managing accuracy is to use what is already known to stratify the sampling and reduce uncertainty by increasing sample size.

There are statistical techniques for estimating uncertainty based on sample size and the shape of distributions. Companies should define an acceptable level of uncertainty for their emission estimates, such as a 95% confidence interval of ±30% (there is a 95% chance the actual emissions are between 30% lower and 30% higher than the reported value). Once an acceptable confidence interval is defined, given the company's unique operating profile, the company can work with in-house or third-party statisticians to determine the minimum number of samples needed to obtain emission estimates for a particular category of sites or for all sites within this uncertainty range.

◯ Establish a cycle for continuous improvement.

The development of a methane emissions inventory is not a static exercise. Adjustments to site selection and sample size — as well as changes in the portfolio from acquisitions, mergers and divestments — can influence the accuracy and uncertainty level of measurement results. Companies should strive to continuously improve these inventories by establishing a protocol to review and assess the efficacy, accuracy, and coverage of completed measurement programs; identify areas for improvement and enhancement; and, establish clear actions with designated owners for future measurements.

An additional benefit of measurement-derived methane emissions inventories is that they can be leveraged for advanced analytics and preventative maintenance, as well as enable greater comparison to independent datasets for verification and improvement, such as developing spatially-explicit inventories that can compare emission estimates from specific geographies. Deviations between datasets are to be expected; however, egregious divergence may indicate potential flaws in the existing sampling approach. Companies should define a process for multi-spatial, multi-temporal, multi-source data comparison to validate the accuracy of emissions estimates and identify areas for improvement.

Conclusion

Today, the oil and gas industry estimates methane emissions through bottom-up emissions factor-based approaches that primarily rely on desktop calculations. As a result, publicly available emissions reports are restricted to estimates that provide little or no direct measurement data. The emission factors used to estimate emissions may include underlying measurements, but these data can be limited with respect to sample size, applicability to current systems, and from different regions and/or operators that make it unrepresentative of current emissions.

Without fundamental changes to how emission inventories are developed, investors, policymakers, regulators and civil society lack the verifiable emissions data necessary to corroborate industry figures or inform key decisions about future energy systems.

In general, the larger the sample size and the higher the frequency of measurements, the smaller the uncertainty of the results.

Part 2: Shifting from 'tell' to 'show' disclosure: improved reporting to drive credibility

Key Recommendations

- Disclose transparent and replicable methods for direct measurement, including methods for determining the representative sample.
- Publish a methane emissions inventory by region, country and/or basin.
- Release summary findings from third-party audits of methane emissions data.

Methane emissions from oil and gas operations are an urgent and material business risk. Over the last five years, there has been a meaningful increase in corporate disclosure on some facets of methane emissions management. Enhanced industry sharing of emissions data and mitigation programs is a critical mechanism to garner investor and public confidence. In 2016, when EDF published its first report on methane disclosure in the oil and gas industry, *Rising Risk*, zero of the 65 companies surveyed reported an individual, quantitative, time-bound methane reduction target. Five companies had committed to a shared target through the ONE Future initiative. Today, at least 25 companies have committed to some form a methane reduction target – either individually or through voluntary industry coalitions – accounting for nearly 40% of global oil and gas production.

Moving forward, for industry to earn credibility with external stakeholders through methane emissions disclosure, the soundness of methods, the care with which they are applied, and the accuracy of the data they produce are all essential.

The recommendations below build on existing best practices and standards of disclosure for corporate target setting established by the investment community, including from the Task Force on Climate-related Financial Disclosures (TCFD) as well as voluntary efforts by industry, including in the Methane Guiding Principles. For example, signatories to the Methane Guiding Principles – a voluntary multi-stakeholder initiative to reduce methane emissions from the global oil and gas value chain – commit to “Increased transparency” by providing “information in relevant external reports on methane emissions data, methodologies used to derive these data, and progress and challenges in methane management.”

At the same time, the TCFD recommends that companies "disclose the metrics and targets used to assess and manage relevant climate-related risks and opportunities where such information is material" as well as describing "performance against targets."[4]

Spotlight: Regulatory Reporting

Although the principal focus of this paper is voluntary reporting by companies and industry coalitions, we recognize the important interplay between regulatory and voluntary reporting on methane emissions.

It is a longstanding practice in environmental reporting for companies to report to governments on a mandatory basis and to other stakeholders - such as investors - on a voluntary basis, through channels such as sustainability reports and CDP filings. Government reporting requirements should be considered a mandatory minimum – a starting point. As investor and public demand for information on ESG issues increases, more companies are choosing to exceed government requirements in their voluntary disclosures.

For jurisdictions with policy and regulations on oil and gas methane emissions, the current mandatory reporting paradigm is generally based on component and equipment-level emissions factors and relies on desktop calculations. Meanwhile, numerous geographies with significant oil and gas activity lack a methane regulatory framework, such that voluntary reporting is the sole mechanism for industry disclosure on methane performance.

In the short term, companies and coalitions have the opportunity to adopt new methods that improve data quality, and show leadership in implementing and disclosing through voluntary reporting. In the coming years, companies and coalitions' reporting could include a combination of measurement-derived top-down and bottom-up methods. Illuminating both methods as complementary could be a constructive phase in the evolution of methods over time. Furthermore, qualitative commentary can provide important context to help the reader understand and interpret data generated through different methods.

In the medium to long-term, governments can and should develop and/or refine their reporting regimes to support the shift to measurement-informed estimates. For example, the EPA has the opportunity to further strengthen its reporting requirements by making it easier for companies to use high quality direct measurement estimates to enrich accuracy of reporting. And the European Union can build its methane policy and regulatory framework on a foundation of high-quality data by utilizing complementary measurement techniques at different spatial and temporal scales and progressively requiring reporting entities to use direct measurement to buttress the accuracy and credibility of regulatory reporting as part of doing business with EU natural gas buyers.

Further, because the success of any performance-based standard depends on accurate performance data, any jurisdiction pursuing a performance-based approach must attach a heightened importance to data quality in reporting, including valid methods that utilize direct measurement of methane emissions.

[4] Ceres, Environmental Defense Fund, Principles for Responsible Investment. 2018. Setting the Bar: Implementing the TCFD Recommendations for Oil and Gas Methane Disclosure. https://www.unpri.org/download?ac=5586

Moving forward, for industry to earn credibility with external stakeholders through methane emissions disclosure, the soundness of methods, the care with which they are applied, and the accuracy of the data they produce are all essential.

Recommendations for enhanced methane disclosure

Critical path information

As companies incorporate methane emissions estimates derived from multi-spatial direct measurements into their inventories, corporate disclosure on methane emissions will have to evolve to reflect this addition. While companies will continue to disclose commonly reported information, such as methane intensity and absolute methane emissions, companies should publish critical facets of their methods and measurements to create the assurance necessary that the figures are representative and accurate.

Methods

The methods used for a multi-spatial measurement campaign and the development of the affiliated emissions inventory will vary by company. Regardless of the variation in methods, three principles must hold: transparency, replicability and accuracy.

Transparency: Enhanced qualitative and quantitative detail is critical to improve trust in, and acceptance of, the underlying process.

Replicability: In order to demonstrate the integrity of the measurement process from year to year, companies will need to provide sufficient detail into their methods such that another company could replicate the approach for their own assets. Replicability of an approach is an important mechanism for instilling confidence in the methods used for estimating methane emissions.

Accuracy: While uncertainty is an inherent component of emissions estimations, it must be publicly acknowledged and managed by disclosing affiliated uncertainty ranges alongside estimates.

In reporting measurement methods, companies should:

- **Cite the procedure(s) adopted for the measurement program.**
  As noted in the section above on Methods, there are various approaches companies can implement to conduct emissions measurement surveys. Disclosure on methane emissions calculations that incorporate bottom-up and top-down measurements should include a

note on which approaches were utilized. While this disclosure is qualitative in nature, it should point investors and other interested parties to the scientific methods for greater research and understanding.

- **Describe the process for developing a corporate-wide sampling plan for direct measurement.**

  As representativeness and sample size are key to an accurate, unbiased sampling process, companies should provide a description of the exercise undertaken as well as the outcomes of this exercise. This information should include:

  - The approach used to develop the sample plan.
  - A description of the asset groups that facilities are divided into, where a stratified. random sampling approach is taken.
  - The absolute number of sites selected for measurement.
  - The number of measurements taken.

- **Disclose the technology(s) deployed and affiliated uncertainty of the measurement results.**

  There are several common modalities for methane emissions measurements. Each of these technologies has unique strengths and limitations that can both enhance, and impede, the accuracy of the measurements. All solutions come with uncertainty, which must be acknowledged by external stakeholders. For example, the range of uncertainty for some of today's conventional emissions factors can be +/- 1000%.[5] An analysis of the site-level quantification approach Other Test Methods 33a estimates an uncertainty of +/- 70%, with a small low bias.[6] This means that for individual measurements, OTM33A has relatively high uncertainty with a 95% confidence that actual emissions are no more than 70% lower or 70% higher than reported, but for a group of measurements, average reported emissions are slightly underestimated. Meanwhile, the technologies commonly deployed for top-down measurements continue to mature. Several recent and ongoing studies have empirically tested the uncertainty of quantification approaches.[7] The results of different technical approaches will have various levels of uncertainty. Therefore, disclosure on technologies and uncertainty should include:

  - The technology(s) used for measurement.
  - The % uncertainty affiliated with the measurement instrument.

[5] United States Environmental Protection Agency. Methane Emissions from the Oil and Natural Gas Industry. https://www.epa.gov/natural-gas-star-program/methane-emissions-natural-gas-industry

[6] Edie, R., Robertson, A. M., Field, R. A., Soltis, J., Snare, D. A., Zimmerle, D., Bell, C. S., Vaughn, T. L., and Murphy, S. M.: Constraining the Accuracy of Flux Estimates Using OTM 33A, Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2019-306, in review, 2019.

[7] See Atmos. Chem. Phys., 2018, 18, 15145-15168; Atmos. Meas. Tech., 2017, 10, 3345-3358; Elem. Sci. Anth., 2019, 7, 1, p.37.

Emissions inventory

Today, corporate-level emissions data are typically disclosed as a single, global, numerical figure: absolute emissions, methane intensity figure, or both. For example, The Oil and Gas Climate Initiative (OGCI) 2019 Annual Report states that the collective methane intensity of the 13 OGCI member companies is "0.29% from a 2017 baseline of 0.32%.[8]" Similarly, in the BP 2018 Sustainability Report the company states that they have achieved a methane intensity of 0.20%.[9]

Today, investors and other external stakeholders are unable to verify these reported figures, nor can they assess performance on a regional basis. In some instances, measured emissions are approximately five times higher than reported figures.[10] As expected, this kind of data disconnect contributes to skepticism and uncertainty in the accuracy of emissions (and reductions) claims and limits the public's ability to assess corporate performance and risk. Going forward, reporting based on measurements from a representative sample can help deliver the additional granularity necessary to enhance the credibility of methane reporting. Enhanced reporting should include a breakdown of emissions data to an appropriate level of specificity that can be reasonably assessed for quality and accuracy by investors, third party auditors, and public stakeholders. This can include:

- Methane emissions AND methane intensity broken out by region, country and/or basin

Audit report

As explored in the next chapter, credible progress towards a methane target — and the underpinning data — should be verified by an independent and technically qualified third-party auditor. Auditors commonly deliver a detailed audit report to their clients, as well as a summary of the findings and recommendations. Companies that undertake audits of their methane data should publish the auditor's summary report to increase the confidence in, and credibility of, the methods and calculations behind reported emissions figures.

[8] Oil and Gas Climate Initiative. Scaling Up Action: Aiming for Net Zero. 2019. Page 5. https://oilandgasclimateinitiative.com/wp-content/uploads/2019/10/OGCI-Annual-Report-2019.pdf

[9] BP. Sustainability Report 2018. 2018. Page 10. https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/sustainability/group-reports/bp-sustainability-report-2018.pdf

[10] Z. R. Barkley, K. J. Davis, S. Feng, N. Balashov, A. Fried, J. DiGangi, Y. Choi and H. S. Halliday, Forward Modeling and Optimization of Methane Emissions in the South Central United States Using Aircraft Transects Across Frontal Boundaries, Geophysical Research Letters, 46, 22, (13564-13573), (2019).

Implementation of enhanced disclosure

Companies should continue to report progress against their methane target publicly through either corporate annual reports or sustainability reports. Disclosure to third party ESG platforms such as the Carbon Disclosure Project (CDP) can also be a valuable resource for stakeholders looking for additional, centralized information related to methane management.

In general, methane emissions reporting benefits from the inclusion of a descriptive, qualitative narrative. This could highlight major successes (and affiliated emissions-reduction results), examples of best practice implementation (e.g. percentage of sites monitored on a quarterly or more frequent basis) or external factors that may influence emissions reductions, such as asset acquisitions or sales. The narrative structure allows stakeholders a better understanding of a company's methane management, as well as important contextual points to interpret the quantitative metrics.

The integration of increased measurements into emissions estimations and inventories will take time. Even as companies embark on the transition to a direct-measurement informed approach, stakeholders will be interested in what steps have been taken to date. Starting at the beginning of this transition, companies can disclose information to highlight incremental progress towards a fully realized program. This may include, but is not limited to:

- For companies that do not estimate emissions derived from measurements, discussing plans to do so in the future.
- Providing operational and technical insights into how the company is proactively expanding its multi-spatial measurement program.
- Findings and learnings from initial, limited direct measurements at several types of sites
- Outlining strategies or governance changes to drive improvements in emissions measurements.

The additional information and insights disclosed will offer stakeholders — for the first time — the ability to validate the accuracy of reported figures. Companies can increase assurance regarding data quality and accuracy by having this information assessed by independent, third-party auditors that have the expertise to sufficiently appraise this information and assure the public about its trustworthiness.

Part 3: Delivering data & methods assurance through external auditing

Key Recommendations

- Hire an external, independent auditor with expertise in the industry and sufficient technical knowledge of oil and gas methane emissions to verify methane data and methods.
- Engage in multi-stakeholder dialogue with auditing firms, industry, academics and non-governmental organizations to define a standard, recognized approach to methane emissions auditing.

Following the wave of methane target setting over the last three years, companies are beginning to report on their progress. This reporting is meant to instill public confidence that the company is on track to reach its goal. This raises the question: Will stakeholders trust the methane data provided by an oil and gas company?

Current public perception of the oil and gas industry paints a skeptical picture. A recent survey found that only 37% of the public trusts the oil and gas industry "to do the right thing" — including reducing methane emissions.[11] Facing decreasing levels of public trust, companies that are serious about their methane targets must take additional steps to ensure the validity and credibility of their publicly reported methane emissions data.

Companies should obtain external, independent audits (also referred to as assurances, verifications, or validations) of all publicly available methane data, calculations, and methodologies and publish the summary findings of these audits on an annual basis.

Benefits of external auditing

Auditing has been common practice in financial reporting for decades. Furthermore, reports that are validated by an external party are considered more valuable by stakeholders.[12] As sustainability reporting grows, external auditing is widely viewed as the most significant value-add to a company's reporting on sustainability metrics.

[11] Houston Chronicle. The oil and gas industry has a problem – and the industry knows it. May 12 2017. https://www.houstonchronicle.com/business/article/The-oil-and-gas-industry-has-a-problem-and-the-11143381.php
[12] Global Reporting Initiative. The External Assurance of Sustainability Reporting. 2013.

Companies that submit their methane data for external audit may realize a variety of benefits, both internal and external, including:

- **Increased credibility of reported data.**
  External audits can give stakeholders greater confidence in the information provided, in so much as the auditing process creates greater assurance that the data and methodologies have been thoroughly vetted. Done right, companies that externally audit corporate methane performance can build trust in their data and methods among investors, partners, and the public.

- **Demonstrated commitment to sustainability.**
  The oil and gas industry is confronted with a growing crisis of confidence among the public regarding its role in the energy transition. A recent survey found that over 70% of the public believes that corporations should have to prove their climate change claims through independent parties.[13] Rigorous external validation of emissions performance is an important investment towards a company's social license to operate.

- **Improved corporate value.**
  Studies show companies that validate sustainability reports face lower costs of capital and commonly yield higher returns.[14] Rating agencies are beginning to incorporate external assurance practices into company scores[15]. Meanwhile, almost 70% of portfolio managers indicate that sustainability reporting should be backed by third-party validation.[16]

Considerations for an impactful external audit

Once a company decides to validate its methane reporting, it will need to select an auditor. While external auditing can be provided by a variety of organizations, almost 90% of assurance statements are provided by three provider types:[17]

- **Accountancy firms (40%): KPMG, Ernst & Young, PricewaterhouseCoopers, Deloitte, and others.**
- **Certification bodies (25%): Organizations providing certification and risk advisory services.**

[13] Corporate Register. Assure View: The CSR Assurance Statement Report. 2008.
[14] Casey, Ph.D., Ryan J, and Jonathan H Grenier, Ph.D. "Save Money by Having Your Sustainability Report Assured." Journal of Accountancy, 11 Apr. 2018, www.journalofaccountancy.com/news/2018/apr/sustainability-report-assurance-services-201815361.html.
[15] The Road Ahead: The KPMG Survey of Corporate Responsibility Reporting 2017. KPMG, 2017.
[16] CPAs. The Preferred Choice for Assurance of Sustainability Information. AICPA, 2018.
[17] Corporate Register. Assure View: The CSR Assurance Statement Report. 2008.

- Specialist consultancies (24%): Subject matter experts such as environmental/sustainability consultants.

There are existing process and procedure standards that govern financial auditing. However, these standards have not transferred comprehensively and globally to sustainability auditing. Instead, many auditors follow their own internal processes. Regardless of the approach, the final audit report should include two essential components:

- Publish the results of the audit.
  The strength of the audit hinges on the ability of external stakeholders to trust the integrity of the audit process. If stakeholders cannot access the findings of an audit, including an assessment of the integrity, accuracy and credible application of the methods used to obtain the data, there is little reason to have confidence in the reporting.

- Disclose the auditing methodology.
  Confidence in an audit is influenced by transparency regarding how the audit was conducted. Auditors should provide clear, explanatory steps that detail how emissions data and methods were assessed, and what factors led to the final conclusion.

Spotlight: The Oil and Gas Climate Initiative

The Oil and Gas Climate Initiative (OGCI) is a voluntary industry effort consisting of 13 oil and gas companies representing roughly one-third of the world's oil and gas market share. In 2018, OGCI took the positive step of publicly committing to achieve a methane intensity target of 0.25% for its members by 2025, with an aspiration of 0.20%.

As a self-styled leadership group, OGCI has the opportunity – and the obligation – to push the frontier of continuously improving data quality as its members address their emissions and report on their results.

The credibility of OGCI's methane target implementation fundamentally depends on the quality of the methods, accuracy of the data, and robustness of the transparency.

In 2019, OGCI stated that its collective methane intensity dropped from 0.32% to 0.29%. However, in addition to lacking the publication of any disaggregation at the company or geographic level, the OGCI number is predominantly based on traditional bottom-up, emission factor-derived estimations known to often understate actual methane emissions. It is not apparent from OGCI reporting the extent to which data is derived from direct measurement as part of the estimation and reporting process, let alone sufficient emissions measurement to inspire confidence in the reported numbers.

Furthermore, since 2019 OGCI took the positive step of enlisting the services of an independent international accounting and auditing firm, Ernst & Young, to perform a review of the individual and aggregated data reported.

However, the work of the firm is limited by existing international auditing standards. Going forward, OGCI can increase the credibility of its reporting by having each member company execute a data review by an established, independent third-party auditor.

OGCI has an important role to play in solving the global methane challenge. OGCI must accelerate efforts to reduce methane emissions at scale, on a credible pathway to meeting its target by 2025 or earlier. To earn stakeholder confidence in OGCI's reported methane numbers, OGCI must:

- Support and adopt methods that incorporate multi-spatial direct measurement to improve data quality.
- Greatly enhance disclosure, including but not limited to: disaggregating its top-line figure, disclosing the proportion of data coming from direct measurement, committing to expand the use of direct measurement, and providing a much more comprehensive view of the mitigation and monitoring activities undertaken by members.
- Ensuring an independent and technically qualified third-party auditor is in place in all member companies to get the highest possible assurance statement at company level and increase the reliability of information at the aggregated level.

Opportunities to improve methane auditing

While the benefits of transparent auditing are known, the ecosystem of standards and practices for high-integrity, third-party methane emissions auditing is a nascent space. This presents both market opportunities and implementation challenges. Without commonly recognized methods for conducting a methane audit, there is a risk that companies will undergo reviews with vastly different approaches. In this instance, no two audits can be sufficiently compared – creating additional and avoidable uncertainty for already skeptical stakeholders.

Herein lies an opportunity for industry, accounting and auditing firms, academics, and non-governmental organizations to work together to define standards for methane auditing excellence that can be leveraged by existing and future third-party auditors meeting the increasing demand for credible methane verification services.

While there are many questions that must be answered on the pathway to designing a methane auditing standard, critical initial questions for discussion include:

- What is the minimum subject matter expertise required to conduct a credible audit of methane emissions data and methods?
- What are the methods for a third-party auditor to assess both the integrity of the methods and the accuracy of the reported figures?
- What is the role and approach of auditors conducting or supporting independent measurements as an added layer of verification?
- What technologies and independent datasets can an auditor use to validate a company's reported methane emissions?
- How can leading academics and other experts best support and engage with the auditor community to support scientific soundness in auditing methods?

Part 4: The path to enhanced data quality and verification

Key Recommendations

- Ensure the right people are secured and supported to enable an effective implementation.
- Integrate implementation into existing processes and protocols.
- Plan ahead for additional data acquisition and management.

Implementation of the recommendations in this paper for enhanced methods, disclosure and auditing for methane emissions may take six months to several years, depending on company size and geographic footprint, and will require committed resources – including designated staff time and capital for technology, services, or both. While each company may take a different approach to incorporating measurements into emissions inventories, all companies can start by answering strategic questions about their people, processes and tools to support the integration of this new way of working into existing protocols.

People

- Are leaders at the corporate level and in the business prepared to unlock resources to fully support implementation?
- Who is best equipped to champion and coordinate this effort, recognizing the multi-stakeholder, multi-function, and multi-geographic nature of this program?
- Who are the right people (by role, function, geography) to participate in a program working group that can support a successful, coordinated roll-out?
- How can the company access qualified experts –internally and/or externally – to deliver key facets of the program design related to measurement technology, statistical sampling, and environmental reporting?

Process

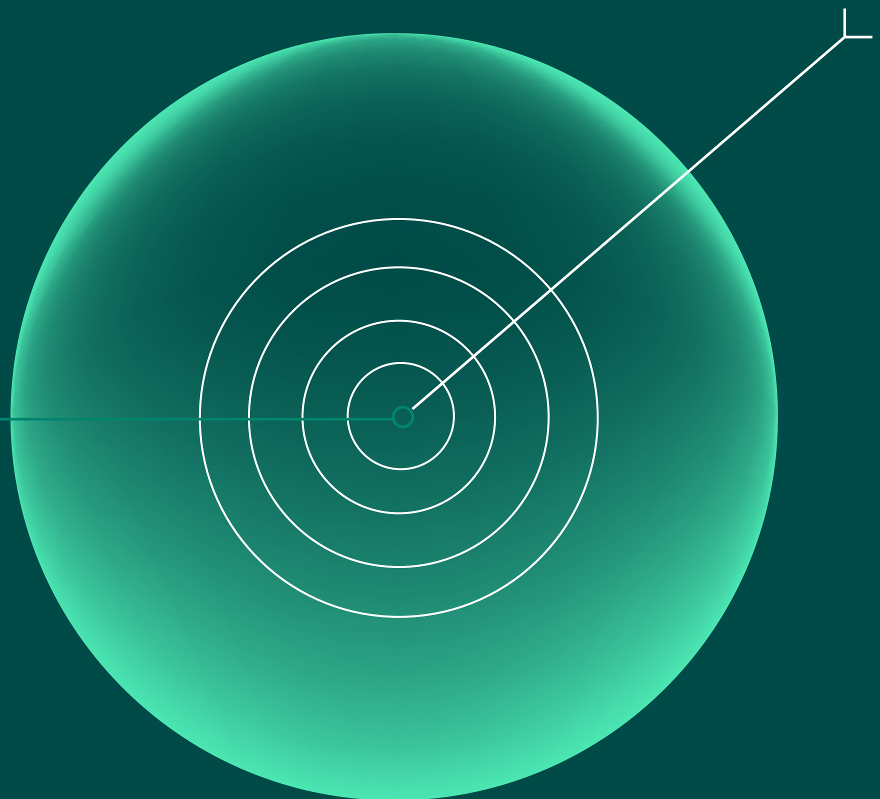
- What project management systems and process protocols are in place that can be leveraged to support implementation?
- How will this program be memorialized as an official, standard work practice and what must be done to coordinate the execution of this document?
- What is the budget for an initial phase of bottom-up and top-down measurements?
- What is the timeline from initiation to complete integration into the annual reporting cycle?
- How can newly collected data enhance and inform ground level methane mitigation strategies?

Tools

- Where is the existing emissions data and information collected and how can this be centralized to inform a representative sampling approach?
- What technologies are used to measure and quantify methane emissions today at various spatial and temporal levels? Are there solution(s) already preferred for this program?
- Where will the measurement data live? How can it be integrated into existing systems to increase efficiency?
- Does the company have a program in place to consider new innovations in monitoring and measurement that can improve accuracy, reduce cost and drive continuous improvement?

Illustrative implementation roadmap

MONTH 0-3	MONTH 3-8
Develop project implementation plan. Collect relevant emissions and operations data. Assess available peer-reviewed methods for site-level emissions quantification. Assess available technologies for top-down and bottom-up measurements.	Select method for conducting multi-spatial measurements. Define measurement sample size and select sites. Select technology(s) for measurement campaign.
MONTH 8-16	**MONTH 16-18**
Conduct multi-spatial measurements at selected facilities. Extrapolate measurements to full population of assets for total emissions estimates. Incorporate uncertainty ranges into total emissions estimates.	Prepare spatially explicit emissions inventory for public reporting. Submit data and methods to third-party auditor. Draft qualitative narrative for corporate reporting.



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