SCIENCE ADVISORY BOARD
A Federal Advisory Committee to the U.S. Environmental Protection Agency

January 17, 2024

EPA-SAB-24-004

The Honorable Michael S. Regan
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

Subject: Transmittal of the Science Advisory Board Report: *Review of the Science Supporting the Proposed Rule Titled, Greenhouse Gas Reporting Rule: Revisions and Confidentiality Determinations for Petroleum and Natural Gas Systems* (RIN 2060-AV83)

Dear Administrator Regan,

The Environmental Research, Development, and Demonstration Authorization Act of 1978 (ERDDAA) requires the Environmental Protection Agency (EPA) to make available to the Science Advisory Board (SAB) proposed criteria documents, standards, limitations, or regulations provided to any other Federal agency for formal review and comment, together with relevant scientific and technical information on which the proposed action is based. The SAB may then make available to the Administrator, within the time specified by the Administrator, its advice, and any comments on the adequacy of the scientific and technical basis of the proposed action. Thus, the SAB is submitting the attached regulatory review report on the scientific and technical basis of the proposed rule titled *Greenhouse Gas Reporting Rule: Revisions and Confidentiality Determinations for Petroleum and Natural Gas Systems* (RIN 2060-AV83)
(GHG Reporting Rule) published in the Federal Register on August 1, 2023.

Section 136(c) of the Clean Air Act directs the EPA to impose and collect a charge for excess methane emissions from applicable facilities that report to the Greenhouse Gas (GHG) Reporting Program (petroleum and natural gas systems source category) and that exceed statutorily specified waste emissions thresholds. The proposed GHG Reporting Rule would amend reporting requirements with the goals of ensuring that reporting of GHG emissions from petroleum and natural gas systems: are based on empirical data, accurately reflect total methane emissions and waste emissions from applicable facilities, and allow owners and operators of applicable facilities to submit empirical emissions data that appropriately demonstrate the charge owed. The Science Advisory Board (SAB) has reviewed the proposed rule to assess whether the proposed methods for emissions reporting, using empirical data, are accurate and consistent with current scientific understanding of methane emissions.

In conducting this review, the SAB followed the engagement process for review of science supporting EPA decisions outlined in the memo of February 28, 2022, signed by the Associate Administrator in the Office of Policy, the Deputy Assistant Administrator for Science Policy in the Office of Research and Development, and the Director of the Science Advisory Board Staff Office.

The SAB met by video conference on June 23, 2023, and elected to review the scientific and technical basis of the proposed rule. A workgroup of SAB members was assembled to review the proposed rule and a subset of workgroup members responded to charge questions, developed by the group, on topics of interest in the proposed rule. The workgroup led SAB deliberations on the science supporting the proposed rule at a public meeting of the Chartered SAB held on November 30th, 2023. The SAB's advice and comments on the science supporting the proposed rule are provided in the enclosed regulatory review report.

The SAB recognizes the importance of ensuring that GHG emissions reporting is based on empirical data and accurately reflects total methane emissions and waste emissions. However, the SAB finds the approach proposed in the GHG Reporting Rule to report greenhouse gases released in large emission events would result in potential missed events and potential over-estimates of the magnitudes of large events that are detected. In addition, the SAB finds that additional reporting requirements could improve the accuracy of estimates of volatile organic compounds (VOCs) and hazardous air pollutants co-emitted with methane. The SAB recommends that the EPA: (1) perform independent measurements to assess the accuracy of reporting, (2) use an alternative approach for reporting of large emission events based on reconciliation with independent measurements, (3) eliminate the 250 metric tons of carbon dioxide equivalent as an independent threshold for a large emission event, and (4) expand the information available on pollutants co-emitted with methane through mechanisms such as creating data sets of regional produced gas compositions.

The SAB appreciates the opportunity to provide comments on the science supporting the proposed rule. We look forward to receiving the Agency's response.

Sincerely,

/s/

Kimberly L. Jones, Ph.D.
Chair
EPA Science Advisory Board

NOTICE

This report has been written as part of the activities of the EPA Science Advisory Board, a public advisory committee providing extramural scientific information and advice to the Administrator and other officials of the Environmental Protection Agency. The Board is structured to provide balanced, expert assessment of scientific matters related to problems facing the Agency. This report has not been reviewed for approval by the Agency and, hence, the contents of this report do not represent the views and policies of the Environmental Protection Agency, nor of other agencies in the Executive Branch of the Federal government, nor does mention of trade names or commercial products constitute a recommendation for use. Reports of the EPA Science Advisory Board are posted on the EPA website at https://sab.epa.gov.

The SAB is a chartered federal advisory committee, operating under the Federal Advisory Committee Act (FACA; 5 U.S.C. 10). The committee provides advice to the Administrator of the U.S. Environmental Protection Agency on the scientific and technical underpinnings of the EPA's decisions. The findings and recommendations of the Committee do not represent the views of the Agency, and this document does not represent information approved or disseminated by EPA.

U.S. Environmental Protection Agency
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Final Science Advisory Board Report: *Review of the Science Supporting the Proposed Rule Titled, Greenhouse Gas Reporting Rule: Revisions and Confidentiality Determinations for Petroleum and Natural Gas Systems* (RIN 2060-AV83)

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ACRONYMS AND ABBREVIATIONS

CAA	Clean Air Act
CH_4	methane
CO_2	carbon dioxide
EJ	Environmental Justice
EPA	U.S. Environmental Protection Agency
ERDDAA	Environmental Research, Development, and Demonstration Authorization Act of 1978
GHG	greenhouse gas
GHGRP	Greenhouse Gas Reporting Program
GHG Reporting Rule	Greenhouse Gas Reporting Rule: Revisions and Confidentiality Determinations for Petroleum and Natural Gas Systems
GWP	Global Warming Potential
HAP	Hazardous Air Pollutant
kg	kilogram
kg/h	kilogram per hour
NASEM	National Academies of Science, Engineering and Medicine
SAB	EPA Science Advisory Board
TCEQ	Texas Commission on Environmental Quality
VOC	volatile organic compound

1. INTRODUCTION

As part of its statutory duties, the EPA Science Advisory Board (SAB) may provide advice and comments on the scientific and technical basis of planned EPA regulatory actions pursuant to the Environmental Research, Development, and Demonstration Authorization Act of 1978 (ERDDAA). ERDDAA requires the EPA to make available to the SAB proposed criteria documents, standards, limitations, or regulations, together with the relevant scientific and technical information on which the proposed action is based. Based on this information, the SAB may provide advice and comments. Thus, the SAB has reviewed the scientific and technical basis of the proposed rule titled *Greenhouse Gas Reporting Rule: Revisions and Confidentiality Determinations for Petroleum and Natural Gas Systems* (RIN 2060-AV83) (GHG Reporting Rule) published in the Federal Register on August 1, 2023.[1]

Section 136(c) of the Clean Air Act (CAA) directs the EPA to impose and collect a charge for excess methane emissions from applicable facilities that report to the Greenhouse Gas (GHG) Reporting Program (petroleum and natural gas systems source category) and that exceed statutorily specified waste emissions thresholds. The proposed GHG Reporting Rule would amend reporting requirements in order to ensure that reporting of GHG emissions from petroleum and natural gas systems are based on empirical data, accurately reflect total methane emissions and waste emissions from applicable facilities and allow owners and operators of applicable facilities to submit empirical emissions data that appropriately demonstrate the extent to which a charge is owed. The SAB has reviewed the proposed rule to assess whether the proposed methods for emissions reporting using empirical data are accurate and consistent with current scientific understanding of methane emissions.

In conducting this review, the SAB followed the engagement process for review of science supporting EPA decisions outlined in the memo of February 28, 2022, signed by the Associate Administrator in the Office of Policy, the Deputy Assistant Administrator for Science Policy in the Office of Research and Development, and the Director of the Science Advisory Board Staff Office. The SAB met by video conference on June 23, 2023, and elected to review the scientific and technical basis of the proposed rule. A workgroup of SAB members was assembled to review the proposed rule, and a subset of workgroup members responded to charge questions developed by the group on topics of interest in the proposed rule. The SAB Workgroup consisted of Drs. David Allen (chair of the Workgroup), Susan Anenberg, Tami Bond, Jayajit Chakraborty, Steven Hamburg, David Keiser, Jonathan Samet, and Drew Shindell. The workgroup took the lead in SAB deliberations on the science supporting the proposed rule at a public meeting of the Chartered SAB held on November 30, 2023.

[1] Greenhouse Gas Reporting Rule: Revisions and Confidentiality Determinations for Petroleum and Natural Gas Systems, Federal Register, Vol. 88, No. 146, page 50286, Tuesday, August 1, 2023. [Available at: https://www.govinfo.gov/content/pkg/FR-2023-08-01/pdf/2023-14338.pdf]

2. SAB ADVICE AND COMMENTS ON THE PROPOSED RULE

2.1. Overall Responsiveness to Methane Emission Reduction Program Requirements.

2.1.1 Charge Question 1: Comment on whether EPA's proposed revisions to the Greenhouse Gas Reporting Program (GHGRP) for Oil and Gas are responsive to the requirements of the Inflation Reduction Act's Methane Emissions Reduction Program requirement that the GHGRP is based on empirical data; accurately reflects the total methane emissions (and waste emissions) from the applicable facilities; and allows owners and operators of applicable facilities to submit empirical emissions data. In particular, please comment on the accuracy of the proposed reporting and whether the reporting methods are consistent with current scientific understanding of emissions.

The Inflation Reduction Act (Public Law 117-169, Section 136) requires that

> "Not later than 2 years after the date of enactment of this section [August 16, 2022], the Administrator shall revise the requirements of subpart W of part 98 of title 40, Code of Federal Regulations, to ensure the reporting under such subpart, and calculation of charges under subsections (e) and (f) of this section, are **based on empirical data**, including data collected pursuant to subsection (a)(4), **accurately reflect the total methane emissions** and waste emissions from the applicable facilities, and allow owners and operators of applicable facilities to submit empirical emissions data, in a manner to be prescribed by the Administrator, to demonstrate the extent to which a charge under subsection (c) is owed." [boldface added for emphasis]

EPA's proposal responding to the emission reporting requirements of Public Law 117-169 provides a broad definition of empirical data. Specifically, the proposal states [Federal Register, Vol. 88, No. 146, page 50286, Tuesday, August 1, 2023]:

> "Empirical data can be defined as data that are collected by observation and experiment. There are many forms of empirical data that can be used to quantify GHG emissions. For purposes of this action, the **EPA interprets empirical data to mean data that are collected by conducting observations and experiments that could be used to accurately calculate emissions at a facility**, including direct emissions measurements, monitoring of CH_4 emissions (e.g., leak surveys) or measurement of associated parameters (e.g., flow rate, pressure, etc.), and published data. The EPA reviewed available empirical data methods for accuracy and appropriateness for calculating annual unit or facility-level GHG emissions. The review included both the evaluation of technologies and methodologies already incorporated in subpart W for measuring and reporting annual source- and facility-level GHG emissions and the evaluation of the accuracy of potential alternative technologies and methodologies, with a focus on CH_4 emissions due to the directive in CAA section 136(h)." [boldface added for emphasis]

The SAB assessed whether the proposed methods for emissions reporting are as accurate as possible. We first review categories of emissions, adapted from the analyses of Zavala, et al. (2017) and shown in Figure 1.

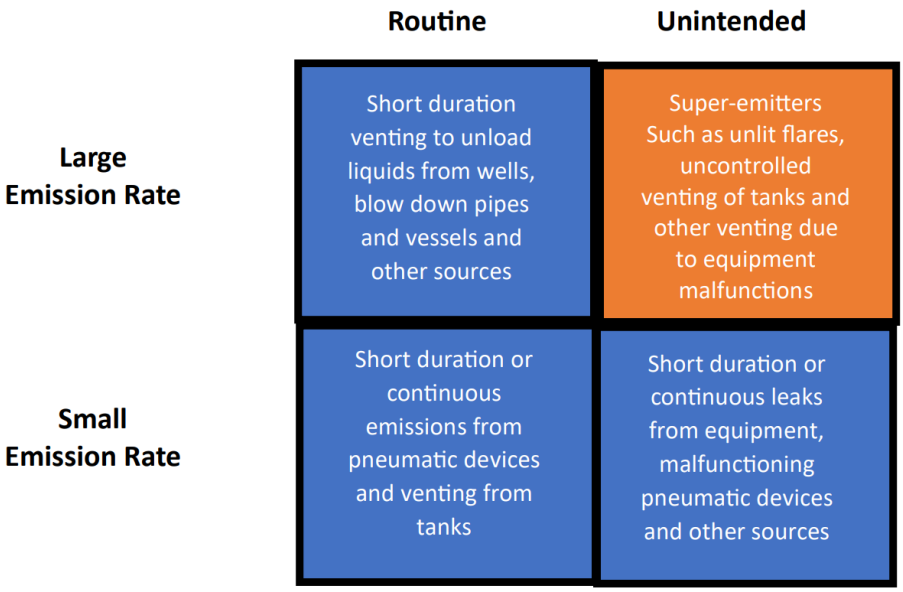

Figure 1: Four major categories of emissions need to be quantified for emissions reporting to be accurate; unintended large emission rate events (upper right quadrant) are the most challenging to accurately quantify (adapted from Zavala, et al., 2017).

Oil and gas facilities can have large emission rates or small emission rates that may be anticipated based on facility design and operations (routine) or that may be due to malfunctions or process excursions (unintended). Current emission reporting tends to capture routine emission sources and has historically included some sources of reasonably anticipated, unintended emissions, such as equipment leaks. However, emission reporting has generally not accurately accounted for large unintended emission events, such as well blow-outs (Pandey, et al., 2019) or other catastrophic failures (Conley, et al., 2016). Reporting through the GHGRP also does not capture emissions from smaller operators that are below the reporting threshold; emissions from such sources may have different distributions of the four categories of emissions than facilities subject to reporting (Omara, et al., 2022). While the contributions from the four categories of emissions vary from region to region (Alvarez, et al., 2018), for national emissions reporting to be accurate and complete, all four categories of emissions need to be accounted for. The EPA, in both its proposed GHG Reporting Rule, and in its rule, *Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review* (methane rule)[2], recognizes all four categories of emissions.

In its proposed rules, the EPA recognizes the importance of the large number of sources with relatively low emission rates (bottom row in Figure 1) by establishing new measurement requirements for both intended and unintended emissions from sources such as pneumatic

[2] Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review (87 FR 74702)

controllers, pneumatic chemical injection pumps, and leaks. These sources, which number in the millions, individually have relatively low emission rates, but in the aggregate constitute a large source of emissions. The EPA has proposed measurement requirements that would generate, over a period of multiple years, direct measurements for most of these individual sources at facilities required to report emissions.

The EPA also recognizes the importance of emission sources that are episodic, but when emitting, can have high emission rates (upper row in Figure 1). Some of these large, episodic emission rate sources are captured in current reporting. For example, pipeline blowdowns, in which the contents of a pipe are vented to the atmosphere, are currently reported and can be accurately estimated based on the volume and pressure of gas in the pipe being vented. Other large emission events may be unintended and multiple studies reported in the peer-reviewed scientific literature indicate that these emissions are under-reported (Zavala, et al., 2017; Cusworth, et al., 2021, 2022; NASEM, 2018). To address these large emission rate sources not captured in current reporting, the EPA proposes establishing a new emission reporting category of other large emission events (upper right quadrant in Figure 1). In regions with high frequencies of large emission rate events, the accuracy of total emission reporting, and the attribution of these emissions to specific operators, hinges on the accuracy of the methods used for including large unintended emission events in reported emissions.

The significance and challenges of quantifying large emission events are documented in recent scientific literature. Cusworth et al. (2022) reported large emission rate sources detected using aerial mapping for production sites in the Marcellus, Permian, San Joaquin, Denver-Julesberg, and Uintah production regions. Point sources detected by the aerial mapping had emission rates ranging from 10 to 10^4 kg/h. Coupled aerial and ground observations, with a range of detection limits, done at a variety of scales, indicate that these large emission events contribute an important but variable fraction of emissions (Stokes, et al., 2022; Kunkel, et al., 2023). Sampling in multiple production regions has also found that large emission sources had a range of durations ranging from hours to weeks (Stokes, et al., 2022; Wang, et al., 2022; Cusworth, et al., 2021). These, and other studies, indicate that: large emission events constitute an important fraction of total emissions in many regions; a variety of emission measurement methods, with varying detection limits, can detect large emission sources; and the sources are numerous and episodic, with durations that are often relatively short.

In its proposed GHG Reporting Rule, the Agency defines an emission rate threshold of 100 kg/h for other large [unintended] emission events. In addition, in its methane rule proposal (reviewed by the SAB, U.S. EPA Science Advisory Board, 2023), the EPA establishes the ability of independent parties, using certified emission measurement technologies, to detect and report super-emitting sources with instantaneous emission rates >100 kg/h. Accurate reporting of annual emissions due to large unintended emission events through the Greenhouse Gas Reporting Program (GHGRP) would require (1) accurately capturing all events; (2) accurately estimating event duration and (3) estimating the rate of emission across the duration of the event.

When large emission events have been detected using short-duration measurement methods, the total release subject to reporting is determined by multiplying the observed rate by an

emission event duration. The relatively short duration of many large unintended emission events may cause over-estimates of *individual* emission events if default durations in the proposed GHG Reporting Rule are used. Event duration consists of a time from emission onset to detection and a time from detection to mitigation. Time from detection to mitigation can be well established, but time to detection can have significant uncertainty. In the GHGRP proposal, operators have the opportunity to provide data on the time to detection for events. These operator-provided data could include process data, and the time since the last periodic emissions measurement that did not detect the event. If operational data or periodic measurements data are not available, a default value of 182 days has been proposed as a time to detection. Chen, et al. (2023) examined the impacts of these assumptions on reported emissions using a conceptual example of a tank over-pressure event. Process parametric data could detect an event (e.g., a tank pressure gauge detecting a tank over-pressure event leading to a release). If process data were not available, the time since a previous measurement might be used to determine the duration of the event. This time since a previous measurement would average 91 days if routine inspections were performed semi-annually. If no inspection data were available, the default value of 182 days proposed by the EPA would be used. The use of the time since the last periodic inspection or the default value of duration would mean that a 100 kg/h event would have an assumed time to detection of 2000-4000 hours (91-182 days). Observational evidence, however, indicates that most events have durations of less than a day (Wang, et al., 2022). This difference in time to detection would change the estimated emission for a 100 kg/h *individual* event from an expected value of <2,000 kg to ~200,000-400,000 kg.

While emissions from *individual* events might be over-estimated using the methods in the proposed GHG Reporting Rule, the intermittent nature of emission events will also cause *individual* emission events to be missed by periodic sampling. Since the events are intermittent and short duration, not all events will be detected in any periodic sampling.

An additional challenge in characterizing the emissions from *individual* events is the variability in emission rate over the duration of an event. Most methane emission measurements that would detect an emission rate >100 kg/h are taken at a single moment in time and the EPA has recognized that emission rate "may not be representative of the annual CH_4 emissions from the facility, given that many emissions are episodic" (Federal Register Vol. 88, No. 146, page 50291, August 1, 2023). The single moment in time of emission measurement may also not be representative of the individual emission event since emission events are both episodic and variable in emission rate. For example, a process excursion that results in equipment over pressurization could have an emission rate that rapidly decays over the duration of the event as pressure is reduced in the equipment. Depending on how an event duration is defined (for example, only those times with emission rates >100 kg/h or the entire duration of the event) and other factors, emission rate variability during an event leads to uncertainties in estimating the overall emissions from the event.

The overall emissions reporting that would emerge from the EPA's proposed GHG Reporting Rule would most likely be larger event emission estimates at a smaller number of locations than is actually occurring, with uncertain impacts on total regional emission estimates.

In addition to potential inaccuracies in reporting large emission events, the proposed approach will have difficulties in assessing whether the large number of smaller emission rate sources (bottom row in Figure 1) are accurately represented. In the proposed reporting, operators of facilities subject to reporting through the GHGRP will be required to perform source level measurements of small emission rate sources. These additional measurements would generate, over a period of multiple years, direct measurements for most of these individual sources at facilities required to report emissions. In any single year, however, the measurements on a limited number of sources for each facility would need to be extrapolated to cover all of the sources for that facility. A single facility can include many diverse sources. For example, a single facility would include all of an operator's production sites in an oil and gas production basin, potentially including hundreds to thousands of sites, with very different characteristics. Extrapolation of emission estimates from sites at which measurements are made in a single year, to all sites, will introduce uncertainty into reported emissions (Schissel, et al., 2023). Careful selection of statistically representative sites can minimize uncertainties, but selecting a statistically representative sample each year can be difficult if coupled with the objective of sampling all sites over a multi-year period. Thus, while the EPA's proposed approach for small emission rate sources does account for the relevant emission categories and increases required emission measurements for these sources, inherent limitations in quantification may prevent sites from achieving accurate reporting.

The SAB finds that the EPA's proposed approach to reporting the greenhouse gases released in large emission events would result in potential missed events, and potential over-estimates of the magnitudes of large events that are detected. The SAB also notes the potential for inaccurate reporting of smaller emission rate sources that have not been directly measured. The proposed emission reporting methods also do not allow for an effective, independent assessment of the accuracy of reporting.

In discussing how accuracy of emission estimates might be achieved, as required by Section 136(c) of the Clean Air Act, it is worthwhile to review the scales at which reporting and verification can occur. *Source-level* emission estimates are possible for specific emission locations or pieces of equipment; reporting requirements will produce many new source-level measurements. *Site-level* emission estimates encompass many sources of different types on a single site, including those that may not be identified for measurement. *Facility-level* emission estimates, where the term *facility* is defined in reporting requirements, may include the output of many sites that belong to a single operator. *Basin-wide* estimates give the total emissions attributable to sites and facilities within an air basin, and to the extent that features of sites and facilities are similar within a basin, the comparison of these totals with the sum of estimated emissions provides guidance for under- or over-estimates at individual contributors.

One strategy to achieve accurate reporting of the net effect of small numbers of large emission events, as well as the large number of small emission rate events, would be to use data from sampling of very large numbers of sites to establish site-level emission factors for particular regions and facility types. These site-level emission factors would capture effects, such as emission event duration, that are difficult to quantify. These data would serve as default emission factors for sites where site-specific monitoring to determine emission factors was not conducted. Alvarez et al. (2018) demonstrated an approach in nine production basins that

estimated emissions from a statistically representative set of site-wide measurements that was then extrapolated to the entire region. These totals were then compared to regional emissions determined by a basin-wide mass balance approach. This work indicates that statistically representative, site-wide emission measurements for individual sites can produce emission estimates that are closely aligned with regional total emissions. Representative site sampling is not yet available for every basin. Developing such data sets might draw on site-level measurements made by third parties on a routine basis, similar to the approach utilized in the collection of the data reported by Alvarez et al. (2018), or by operators or their designees, as measurement and reporting frequencies are expected to increase under the proposed rule. Routine independently produced site-wide measurements selected to ensure statistical representation would capture temporal shifts in emission rates, more accurately reflecting any reductions or increases in emissions rates in near real time. Such independent site-wide data collections would qualify for support from the funds allocated for measurements in this title.

Basin-wide total emission rates would be a complementary confirmation of accuracy. Such basin-wide rates can be collected with a much smaller number of observations than emissions from all *individual* facilities. A technique that has been employed by federal agencies, such as the National Oceanic and Atmospheric Administration (NOAA) (Alvarez, et al, 2018, NASEM, 2018), has been to sample the air entering and leaving a region, which can represent the influence of tens of thousands of sites. In this "mass balance" approach, the difference in the mass of methane entering and leaving the region is the amount emitted in the region. Other approaches are possible and could include area wide satellite measurements of basins, coupled with inversion algorithms to estimate basin-level emissions (Jacob, et al., 2022). Measurements of production regions could be established using government-sponsored monitoring. Because these basin-wide assessments of total emissions aggregate emissions over very large numbers (thousands) of sites, the overall influence of infrequent large emission events, as well as the entire population of smaller and more constant sources, are effectively sampled. Not all events are captured, but a representative sample of events is captured in each sampling period (typically a day or less), and the sampling is repeated on a monthly to quarterly basis. The data obtained by this approach is the basin-wide emission total, which is the quantity relevant to climate impact. Basin-wide total emissions can be compared to reported emissions for a region, using the type of gridded emission inventories now being developed by the Agency (Maasakkers, et al., 2023), providing an effective independent assessment of the overall accuracy of emissions reporting.

Comparing basin-wide total emissions to emission reporting will require estimation of emissions from non-reporting sources. Sources in the oil and gas sector that are below the reporting threshold for the GHGRP include production sites with relatively low production rates. These sites have different emission characteristics than sites with larger emission rates (Omara, et al., 2022) and the accuracy of basin level extrapolations for these sources will introduce uncertainties. The EPA, however, must address this uncertainty in preparing its annual Greenhouse Gas Inventories and using basin-level mass balance approaches could improve the accuracy of both the GHGRP and the annual Greenhouse Gas Inventory.

The SAB recommends that EPA convene a group of experts to advise on how to create a statistically-robust, regionally-specific sampling approach to developing site-level emission factors that can be measured on a regular basis.

The SAB also recommends that EPA use an approach to improving the accuracy of reported emissions, and the fees assessed based on those emissions, that requires minimizing differences with regionally observed emissions. If this process results in significant differences between GHGRP reported emissions and basin-level observations, the reported facility-level GHGRP emissions would need to be adjusted. Refining this adjustment procedure would require input from a range of stakeholders.

Finally, the SAB recommends that EPA sponsor regular basin-wide assessments of total methane emissions in collaboration with other government agencies and compare those assessments to reported emissions, providing an independent assessment of the accuracy and completeness of emissions reporting.

Basin-wide measurements will provide an assessment of the accuracy of emissions reported on a regional scale and determine discrepancies that need to be accounted for to achieve accurate reporting. Reconciling any differences in the aggregate GHGRP reported emissions for each basin, with basin-wide measurements, can be done in multiple ways.

One approach is currently being tested by the State of Colorado. In this approach, if the reported emissions and the basin-wide observed emissions do not agree, operators may be required to adjust their reported emissions by an average factor based on the ratio of observed to reported emissions. So, for example, if observed basin level emissions from oil and gas sector sources are 50% higher than reported emissions from the sector, reporters would be required to increase their reported emissions by an amount that accounts for that difference (50%, on average). Operators who could demonstrate through their own site-level measurements that they have lower than average emissions from all sources, including large emission events, could use their company level data for reporting. However, if some operators use lower than average adjustments, and all other operators use the average adjustment, total reported emissions would be lower than basin-level observations. Regular revisions would need to be made to site-level emission factors and adjustment factors to reflect those operators with demonstrated low emissions so that, on average, emissions adjustments are consistent with basin wide measurements.

Multiple measurement technologies, described in the current scientific literature, could be used to establish basin-wide total methane emissions and the basin-wide totals could be frequently updated. This type of report and verify system, using representative basin-wide emission measurements coupled with other measurement-based reporting, would provide a more accurate approach to emission reporting than the current GHGRP proposal and accurately report temporal trends. Such an approach can be transparent and uncertainty levels can be determined and used to select the sampling performed in each basin. Basin wide total emissions, supplemented by other sampling, can help identify portions of the inventory that have inaccurate reporting, whether they are large emission events, large numbers of small

emission rate sources, or other categories of emissions. This approach is rapidly implementable based on the current state of emission measurement technologies and a growing capacity within agencies across the U.S. government. Further improvements to this approach or alternative approaches can be expected to be possible as technologies improve, and the EPA could periodically re-evaluate the technological aspects of the program.

The SAB recommends that EPA use an approach to improving the accuracy of reported emissions, and the fees assessed based on those emissions, that requires minimizing differences with regionally observed emissions. If this process results in significant differences between GHGRP reported emissions and basin-level observations, the reported facility-level GHGRP emissions would need to be adjusted. Refining this adjustment procedure would require input from a range of stakeholders.

2.2. Emission Categories and Thresholds

2.2.1 Charge Question 2: Comment on the scientific and technical basis of the definition of a separate emission category of "other large emission events" using a threshold of a detected methane emission rate of 100 kg/hr or an absolute magnitude of 250 tons of CO_2 emitted. Comment on whether EPA's choices of emission thresholds are reasonable, and the challenges that are likely to arise in detection of emissions at the 100kg/hr rate using emerging measurement technologies.

In the GHG Reporting Rule, the EPA has proposed two emissions thresholds for determining whether emissions from "other large release events" must be reported. These thresholds are a detected methane emission rate of 100 kg methane/h or an absolute magnitude of 250 tons of CO_2 emitted. The Science Advisory Board (SAB) has previously commented on the 100 kg methane/h emission event threshold in its analysis of the methane rule (U.S. EPA Science Advisory Board, 2023). In its analysis, the SAB concluded that "using a rate-based definition of a super-emitter is appropriate and that the super-emitter threshold of 100 kg/h is a reasonable boundary that captures the largest events that constitute an important source of emissions in many regions." The SAB also noted that the threshold could be periodically re-evaluated.

The inclusion of a separate and independent threshold of 250 metric tons of carbon dioxide equivalent is more problematic. A total emission event magnitude of 250 metric tons of carbon dioxide is equivalent to emissions of 10,000 kg of methane, assuming a Global Warming Potential (GWP) of 25. An emission rate duration of 100 hours (4.2 days), for a 100 kg/h event, produces 10,000 kg of emissions. An emission event duration of 182 days, a default duration value in the proposed rule, requires an emission rate of only 2.4 kg/h to generate 10,000 kg of emissions. There are a very large number of emissions that would exceed a 2.4 kg/h threshold, and since many of these sources will not have operational data to establish duration, large numbers of sources would fall into the large emission event category using the proposed threshold of 250 metric tons of carbon dioxide equivalent.

While low emission rate events with a long duration would exceed the proposed total emission threshold, an event with an emission rate >100 kg/h with a very short duration would have

relatively small total emissions despite having a high emission rate. An event with a rate of 100 kg/h with a duration of one minute results in emissions that are <2 kg.

The SAB recommends that EPA eliminate consideration of the 250 metric tons of carbon dioxide equivalent as an independent threshold for a large emission event.

2.2.1 Charge Question 3. Comment on whether the EPA should consider increased reporting to provide data on non-methane emissions from sources reported through the GHGRP.

Other hydrocarbon species are generally co-emitted with methane, and additional reporting could improve the accuracy of volatile organic compound (VOC) emission and Hazardous Air Pollutant (HAP) emission reports. VOC emissions from pneumatic controllers provide a case study of the magnitude of co-emitted VOC species. In work performed for the Texas Commission on Environmental Quality (TCEQ), Torres et al. (2023) estimated the magnitude of VOC emissions from pneumatic controllers at oil and gas facilities in the State of Texas. Pneumatic controller emissions are one of the largest sources of methane emissions from the oil and gas sector and in proposed rules the EPA is proposing to require the use of zero emission controllers. Torres, et al. (2023) estimated that the VOC emission reductions in Texas from this action alone would be comparable in magnitude to the methane emission reductions. Since production basins in Texas include non-attainment regions for criteria air pollutants, these emission reductions can be significant in air quality planning activities. The accuracy of estimates of VOCs and hazardous air pollutants co-emitted with methane is dependent on the accuracy in produced gas compositions, and these compositions vary widely between and within production regions. Produced gas composition data are relatively sparse in Texas and virtually unavailable in some other parts of the United States. More data collection on produced gas compositions, including data on co-emitted hazardous air pollutants such as benzene, would be valuable for both air quality planning and Environmental Justice (EJ) analyses. These data could be aggregated at the county level, as done by Torres, et al. (2023), or some other relevant spatial scale.

Data on emission compositions can also be valuable in attributing the sources of methane emissions, which will be important in interpreting basin-level emission totals. For example, emissions from tanks on production sites will have much higher fractions of ethane, propane and higher molecular weight hydrocarbons than emissions of produced gas (Allen, et al., 2017). Chemical fingerprints of individual sources, which can be estimated based on the composition of produced gases, can be used to distinguish emission sources or source sectors (Allen, 2016; Cardoso-Saldaña, et al., 2019).

The SAB recommends that EPA expand the information available on pollutants co-emitted with methane through mechanisms such as creating data sets of regional produced gas compositions and how they vary across production site components and oil and natural gas value chains.

3. SUMMARY OF FINDINGS AND RECOMMENDATIONS

SAB findings regarding the approach proposed in the GHG Reporting Rule to report greenhouse gases:

- The SAB finds that the EPA's proposed approach to reporting the greenhouse gases released in large emission events would result in potential missed events, and potential over-estimates of the magnitudes of large events that are detected. The SAB also notes the potential for inaccurate reporting of smaller emission rate sources that have not been directly measured. The proposed emission reporting methods also do not allow for an effective, independent assessment of the accuracy of reporting.

- Additional reporting requirements could improve the accuracy of estimates of volatile organic compounds (VOCs) and hazardous air pollutants co-emitted with methane.

SAB recommendations:

- The SAB recommends that EPA convene a group of experts to advise on how to create a statistically-robust, regionally-specific sampling approach to developing site-level emission factors that can be measured on a regular basis.

- The SAB also recommends that EPA use an approach to improving the accuracy of reported emissions, and the fees assessed based on those emissions, that requires minimizing differences with regionally observed emissions. If this process results in significant differences between GHGRP reported emissions and basin-level observations, the reported facility-level GHGRP emissions would need to be adjusted. Refining this adjustment procedure would require input from a range of stakeholders.

- The SAB recommends that EPA sponsor regular basin-wide assessments of total methane emissions in collaboration with other government agencies and compare those assessments to reported emissions, providing an independent assessment of the accuracy and completeness of emissions reporting.

- The SAB recommends that EPA eliminate consideration of the 250 metric tons of carbon dioxide equivalent as an independent threshold for a large emission event.

- The SAB recommends that EPA expand the information available on pollutants co-emitted with methane through mechanisms such as creating data sets of regional produced gas compositions and how they vary across production site components and oil and natural gas value chains.

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