Guidance document:
Reconciliation and Uncertainty (U&R) in methane emissions estimates for OGMP2.0

TABLE OF CONTENTS

1 Introduction

Reconciliation is the process of comparing source-level (Level 4) inventories with independent site-level measurements to produce Level 5 asset emissions estimates. Site-level measurements complement - rather than replace - source-level estimates, and the process of reconciliation helps improve accuracy, thoroughness and confidence in reported emissions. Reconciliation is an iterative process of investigation, year over year, and should not be thought of as a one-off comparison of two independent values. The process, like the knowledge, will evolve over years – the focus is on making credible progress year over year.

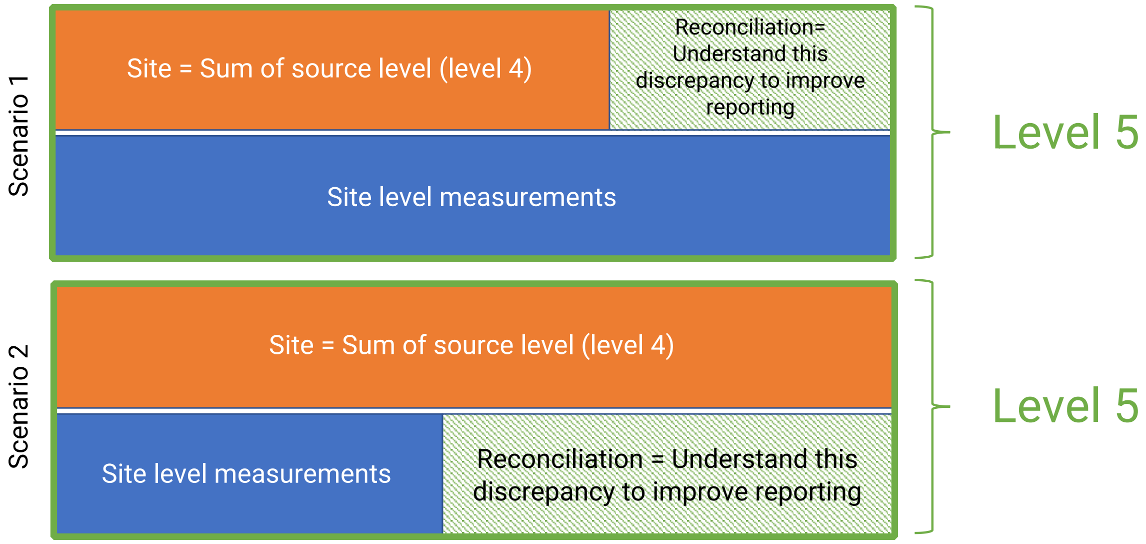

Figure 1: Visual depiction of the reconciliation principles of reported emissions comparing Level 4 emissions estimates with site level measurements to produce a Level 5 asset estimate.

Emissions characteristics vary greatly across assets and between segments (upstream, midstream, downstream), and no single sampling strategy can be defined *a priori* that applies to all situations. **Therefore, this guidance offers considerations for operators to approach L4 inventory and L5 estimate development, including reconciliation, but is not prescriptive.** It is recommended that operators share case studies to support a growth in common knowledge over the next several years.

(i) The measurement strategies and reconciliation process will require both judgment and justification to achieve a robust result.
(ii) Operators will build up experience that will allow for the refinement of measurement and reconciliation over time, thereby achieving higher quality results.
(iii) Operators should focus their most robust measurement efforts on reducing uncertainty associated with larger emissions sources within their portfolios.
(iv) Transparency of method and reporting of complete results is critical.

2 Nomenclature

Asset/operating unit: A logical business or operating unit (e.g. individual processing plants, gathering facilities, or offshore platforms; producing basins; regional assets; Liquified Natural Gas (LNG) operating units, pipeline networks with all the components, etc.). Partner companies can determine the appropriate level at which they describe their participating facilities, within the following criteria:

- An operation/asset unit should be defined such that all facilities or sites of the unit are participating in the program (e.g. several production batteries within a sub-region are listed as one operation/asset).
- An operation/asset unit that is defined by geographical bounds should typically be smaller than a country, and could be one site / facility or a group of these.

Site/facility: collection of sources with some relation to one another as a subdivision of an asset/operating unit (e.g., production battery, compressor station, processing plant, transmission station, pipeline segment(s), pipeline networks, liquefaction plant, etc.). This could match the boundary of an asset/operating unit if appropriate, but should generally be no larger than an asset/operating unit.

For a Distribution System Operator (DSO) particularly, the main assets are generally a lengthy pipeline system and a high number of service lines/connections and pressure regulating stations. In this context, a site/facility should be interpreted as an assembly of similar types of emission sources.

Source: a component within a process or equipment that releases methane to the atmosphere either intentionally or unintentionally, intermittently or persistently.

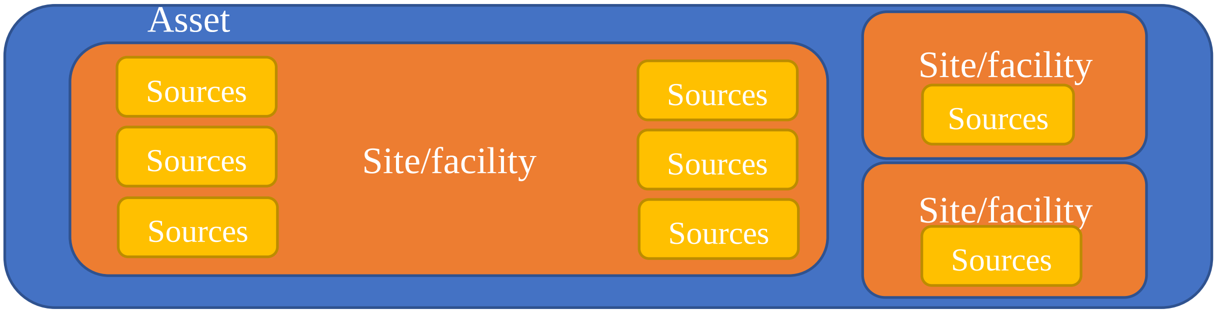

Figure 2: Schematic of the relationship between an asset/operating unit, sites/facilities and sources

Population of sites/facilities: a collection of similar sites/facilities that can viewed as a whole rather than individually (e.g., collection of production batteries, collection of pipeline segments, collection of compressor stations).

Population of sources: a collection of components that operate in similar service to each other that can be viewed as a whole, rather than individually. They may be categorized by make/model of component, operating status, process stream, or other criteria.

Emissions distribution: a description of the probability of observing a particular emission rate for a single measurement out of many possible measurements (*e.g.*, at a single point in time or for an individual measurement out of a population). An emissions distribution is built up through performing statistical sampling of a source or site over time, or a population of sources or sites.

> **Normal (Gaussian) distribution**: a symmetrical bell-curve probability distribution where the mean, median, and mode are all equal.[1]
>
> **Skewed and fat-tailed distributions**: a skewed distribution is an asymmetrical distribution where one tail is longer than the other (typically the right-hand one). Fat-tailed refers to having tails in the distribution that are heavier than represented by an exponential function (i.e. the probability of high emissions is greater relative to that of the one expected from a normal distribution).[2]

Skewed and fat-tailed distributions are more complicated to characterize (particularly under the situation where there is also temporal variation). Figure 3 illustrates a generic, skewed and fat-tailed distribution.

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[1] Normal distributions refer specifically to the Gaussian statistical distribution of values around the average and not to whether or not an emission is normal or abnormal in operation. The word ‘normal’ does not imply anything about the normal/abnormal characteristics of operations at the site.

[2] The presence of a fat tailed distributions has been found across geographies and types of production (ref Robertson et al., Zavala-Araiza et al., Negron Gorchov), and across segments of the distribution supply chain: upstream (ref Robertson et al), midstream (ref Mitchell et al.), and downstream (ref Weller et al and Maazallahi et al.). They are also present at the source-level (Brandt et al., Allen et al) as well as site-level (Alvarez et al.).

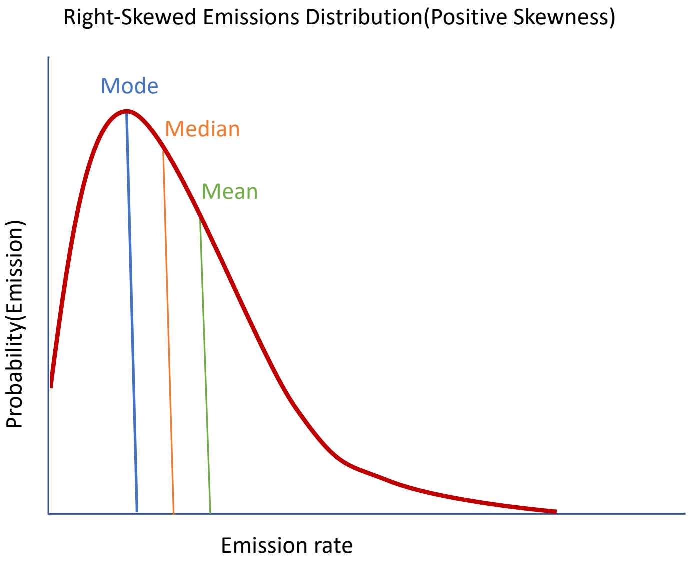

Figure 3: Generalized probability distribution with positive (asymmetric) skew.

The figure represents several different scenarios:

> 1: The y-axis represents the probability of measuring a particular site-level emission rate for a site at an instant in time, or
> 2: The y-axis represents the probability of measuring a particular site-level emission rate for an individual site among a population of sites, or
> 3: The y-axis represents the probability of measuring a particular emission rate from a source among a collection of similar sources.

Materiality at asset level: In the annual report, report the vast majority of emissions at level 4 for any given asset.

In practice, this means:

- Prioritize more complete coverage of Level 4 measurements at assets that account for a larger share of operator-level emissions.
- For a given asset, rank all sources of emissions based on best available data (minimum L3)
- Perform L4 on sources that account for a minimum of 70% of the methane emissions from each asset with a justification as to why >90% is not reached.

The percentages described above are applied to a selected relevant year of reference[3] and this year of reference can be reassessed if there are significant changes in operations/methodology (e.g., 20% change of emissions within 3 years).

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[3] Which reflects current operations and can be different from the baseline year, used to set targets

3 Developing L4 and L5 inventories

The development of the level 4 (L4) inventory for an asset/operating unit should be guided by a complete level 3 (L3) inventory. L3 reporting is an inventory of all possible sources across the assets using generic emission factors and company specific activity factors. The L3 inventory can rely on the specific TGD´s generated by the OGMP 2.0 initiative[4] or similar generic emission factors such as described in the United States Greenhouse Gas Reporting Program[5] or the protocol from the Natural Gas Sustainability Initiative (NGSI)[6].

The complete L3 inventory will form the basis for a materiality analysis, both at company and asset level, using the materiality definition (link). The L4 reporting is also an inventory of all possible sources across the assets, but uses company specific methodologies to estimate emissions from each source. Operators should define the company/asset specific L4 emission estimating methodologies appropriate to the source type with consideration for the emissions magnitude (based on the materiality analysis). Operators should focus on the largest (most material) sources first and continue to build an increasingly robust company/asset specific source level emissions estimating protocol over time.

The L4 emission estimating methodologies for a particular source should incorporate measurement in the development. The final methodology could be either:

- repeated source level direct emissions measurement campaigns (one or more times each reporting year);
- company/asset specific emission factors/methodologies (derived from measurement);
- rely on engineering calculations where appropriate (incorporating measurement where possible);
- or any combination therein.

Emissions that are not considered material may continue to rely on L3 quality estimated emissions within the L4 inventory. Sub-sampling for populations of similar sources may be applied as described in Section 4 (Guidelines on sampling and measurement strategy). L4 reporting should include details of the sampling, measurement, and estimation methodologies (including any technology limitations), uncertainty estimates for each measured/calculated emission, and rationale for the approaches.

Source level emissions estimates in the L4 inventory should incorporate variability of emissions over the reporting period for the sources, relationship of source measurements to operating parameters (where appropriate), and an estimate of the uncertainty for both the measurement methods and reported emissions. This is important to facilitate progression to L5. Further, having a credible L4 inventory with defensible uncertainty estimates is vital to evaluate the effectiveness of source level emissions reduction strategies year over year.

L5 reporting emissions estimates build on the L4 inventory through the addition of site-level measurements. **L5 reporting reflects the best estimates and associated uncertainty for each asset** after an operator has performed site-level measurements and conducted reconciliation. The

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[4] https://www.ogmpartnership.com/templates-guidance

[5] https://www.epa.gov/ghgreporting/resources-subpart-ghg-reporting

[6] https://www.eei.org/issuesandpolicy/pages/ngsi.aspx

reconciliation process includes comparison of the sum of source-level emissions estimates at L4 quality to site-level measurements. This comparison improves confidence in accurate reporting at source-level through elucidation of discrepancies between two independent approaches to deriving emissions (sometimes called bottom up vs top down emissions comparison).

To the extent there is no agreement between the sum of source-level estimates and site-level measurements, an operator should endeavor to understand the source of discrepancy and transparently report, incorporating any adjustment (increase or decrease as appropriate) to the asset level (L5) reported value. The operator should then incorporate the learnings into the following year measurement strategy. This could also result in a subsequent revision to the L4 inventory methodologies and uncertainties to the extent the reconciliation identified under- or over-estimates to one or more specific sources.

L5 should include source level emissions inventory (L4), measurement method(s) and technology details, including limitations, should be documented with the results for site-level measurements and reconciliation to produce the L5 reporting. This also includes results where the comparison did not result in adequate reconciliation, but informed subsequent investigation.

The steps for an annual reconciliation for an asset can be generalized as shown below:

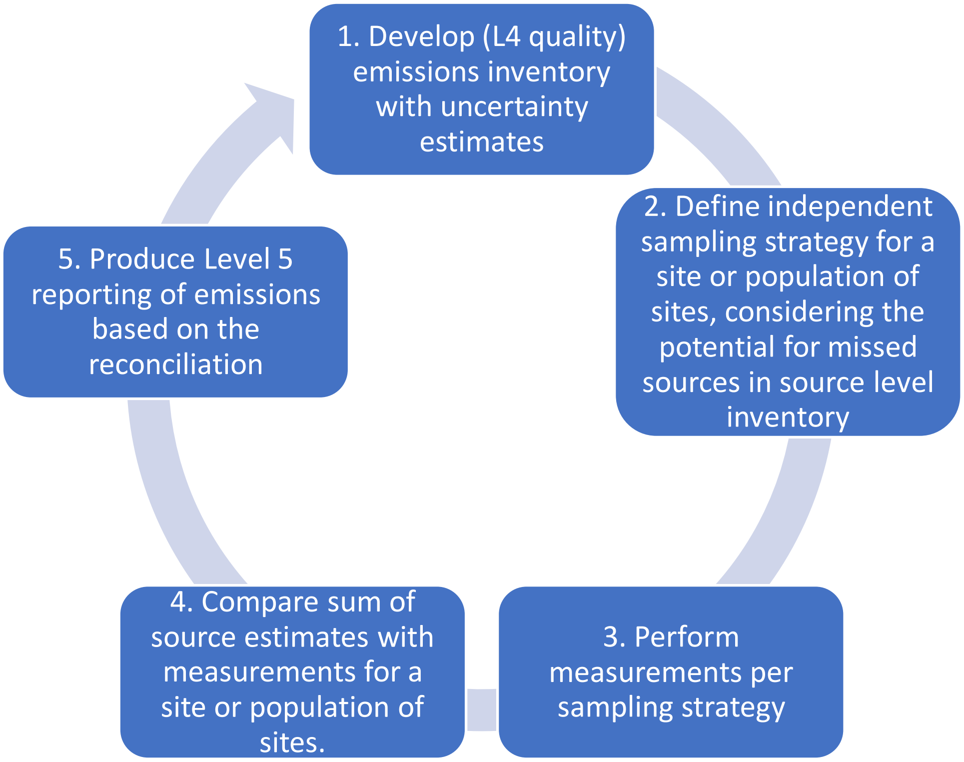

Figure 4: Diagram of the steps for reconciliation, depicted as a continuous cycle as the first year will inform improvements in the next.

Reconciliation approaches may differ but can broadly be achieved on:

1. Unique facilities or small number of facilities basis - In a situation where an operator has detailed temporal information about emissions while developing L4 emissions inventory, ideally through detection and/or monitoring, and can correlate those emissions with the state of an operation, an operator may choose a sampling strategy to ensure that the sum of source-level emissions (i.e. the L4 inventory) is corroborated by site-level measurements at one or more points in time.
2. A population of sites basis - Where an L4 emissions inventory is not available with detailed temporal variation, an operator may instead choose to make sufficient site-level measurements to be representative over time, so as to extrapolate the measurements to an annual average. Monte Carlo analysis (or other appropriate statistical methods) can be used to compare short duration measurements to source-level emissions estimates on different times scales.

Guidelines for Level 5 emissions reporting:

- Site-level measurements shall be conducted **independently** (using independent methods/technologies) than those used for the source-level inventory, though one may inform the approach of the other.
- Reported emissions are **complete**, ensuring material emission sources have not been missed in the source level inventory. Asset level estimates should consider the possibility of rare but significant emission events.
- The **uncertainty** for each, **source-level estimates and site-level** measurements, should be included in the assessment
- Operators should be familiar with the time *variability/status* of operations over the course of site-level measurements **(transient, variable, intermittent and/or steady state**) to aid in interpretation of the measurement.
- This variability/status of operations should be characterized as part of the source-level estimates and site-level measurements. The approach should capture the occurrence of significant intermittent emissions. This could be accomplished by appropriate frequencies of measurements or monitoring (e.g., more frequent than annually), equipment specific monitoring or other suitable approaches.

4 Guidelines on sampling and measurement strategy

Emissions from sources and at a site/facility can vary – sometimes by several orders of magnitude over the annual[7] operating cycle of an oil and gas facility (e.g. variations in the levels of flaring, the occurrence of new leaks, normal variation in operations, turnaround/maintenance schedules). Therefore, a combination of sampling strategy and measurement methods (including the timing and frequency of deployment, detection threshold of the approach, operational conditions), should adequately account for the variable[8] nature of emissions.

Companies can use (and/or rely on data acquired by) any number of relevant technologies that allow for credible measurement at the source or site level. Current examples of measurements to inform source level estimating methodologies include flow meters, high-flow sampling instruments, handheld sensors, or sensors mounted to planes, drones, boats, trucks, etc. Some of these may also be used for site level measurements. Satellite measurement, assuming measurement resolution and detection limit are sufficient to provide site-level measurement information, could also potentially represent an acceptable technology for site-level measurement. Operators should document the type of technology used and measurement methods.

Measurement may include measurement conducted by, or on behalf of, OGMP2.0 partner companies or measurement conducted as part of measurement campaigns undertaken by third parties (e.g. academia, governments, other initiatives, *etc*.) As long as the data are gathered and presented in a demonstrably credible and transparent way, companies can utilize the information and data from relevant measurement campaigns at the source- or site-level.

Level 4 source measurements: The L4 emission estimating methodologies for a particular source should incorporate measurement in their development. The measurements need not be repeated on an annual basis. Operators may (and are encouraged to) continue to revise L4 estimating methodologies to further reduce uncertainty and reflect changes (or learning) over time and so measurements may be repeated or revised from time to time. Measurements should be incorporated in a way that fully characterize emissions from a particular type of source. This could result in a company specific emission factor or a more complex methodology. Where emission factors or other methods rely on measurements of a source, a statistically representative subsample of a population may be used as appropriate.

Level 5 reporting: The frequency for site-level measurements should be dictated using a risk-based approach taking into account the materiality, relative contribution to total emissions, and source of emissions as they are understood for Level 4 reporting based on the operator judgement. This assessment should occur no less frequently than on an annual basis.
Assets where emissions are material and the data suggest that there are very large discrepancies between the emissions quantified using source-level methods and those resulting from site-level measurement, should be candidates for analysis that can lead to more frequent follow-up

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[7] Reporting cycle is annual

[8] Some variation is due to normal operational variation and other variation is due to stochastic (random, unpredictable) emission sources

measurements. Sites which have been validated to contribute minimally should be included with L4 methods.

Those assets where the discrepancies are small, and/or where the absolute emissions levels (or risk of significant, unidentified emissions) are minor, should be subject to less frequent measurement. Assets where low emissions variability is observed should also be candidates for less frequent site-level measurement.

Site level measurements may be performed for an individual site/facility or for a population of sites/facilities.[9] Like the process of reconciliation, sampling strategies will likely evolve over years. Improvement over time, and even discrepancies early on, are expected.

Defining populations of sources or sites/facilities

Where source or site/facility types are sufficiently similar to permit the grouping, measurements may be conducted on a population basis. Statistical sampling enables emission factor development to represent a population of sources for L4 inventories. It could also be a useful and cost-effective approach to conducting site-level measurements where sites are similar with respect to design, operation, age and other factors to warrant such aggregating, *e.g.* combined onshore wells, gathering systems, pipeline segments, etc. comprising an entire asset.

Scientific studies of methane emissions from oil and gas infrastructure around the world have highlighted a tendency for emissions distributions to not follow a Gaussian distribution.[10] There is a tendency for both source-level and site-level emissions to follow a skewed and sometimes 'fat tailed' distribution. While conceptually, some emissions distributions could follow a Gaussian distribution, it is incumbent upon the company to validate the emissions distribution assumptions to support the appropriate sampling strategy.

The challenge for statistical sampling of skewed distributions may apply both at the source and site level. Skewed and fat tailed emissions distributions[11] have been observed at the facility level (e.g., a few emission sources constitute a large share of emissions) as well as at the source level

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[9] As noted in the introductory section, the same principles may be applied to populations of sources when developing L4 emission factors.

[10] Several studies point to skewed distributions at the source (component level): see, for example:
(a)Brandt, A. R., Heath, G. A., & Cooley, D. (2016). Methane leaks from natural gas systems follow extreme distributions. *Environmental science & technology*, *50*(22), 12512-12520. (b) Allen, D. T., Torres, V. M., Thomas, J., Sullivan, D. W., Harrison, M., Hendler, A., ... & Seinfeld, J. H. (2013). Measurements of methane emissions at natural gas production sites in the United States. *Proceedings of the National Academy of Sciences*, *110*(44), 17768-17773. (c) https://www.carbonlimits.no/wp-content/uploads/2017/11/LDAR_In_Europe.pdf
And site/facility level. See, for example:
(d) Zavala-Araiza, D., Alvarez, R. A., Lyon, D. R., Allen, D. T., Marchese, A. J., Zimmerle, D. J., & Hamburg, S. P. (2017). Super-emitters in natural gas infrastructure are caused by abnormal process conditions. *Nature communications*, *8*(1), 1-10. (e) Mitchell, A. L., Tkacik, D. S., Roscioli, J. R., Herndon, S. C., Yacovitch, T. I., Martinez, D. M., ... & Robinson, A. L. (2015). Measurements of methane emissions from natural gas gathering facilities and processing plants: Measurement results. *Environmental science & technology*, *49*(5), 3219-3227.

[11] Could be mathematically described by other types of non-Gaussian statistical distributions such as Weibull, Gumbel, Log-Normal, Generalized Extreme Value Distribution, etc.
https://www.sciencedirect.com/topics/mathematics/skewed-distribution

(e.g., an equipment malfunction), giving rise to disproportionately high share of emissions within this single source type.

The number of samples required to characterize such a distribution will depend on the tightness of the expected distribution as well as the magnitude of skew. For instances where an operator has no information about the expected distribution and emissions are material, a large number of samples may be necessary to understand the distribution, which could then be used to inform future reduced sampling strategies.

Where only a few measurements have been conducted, there is an increased risk that one measurement result will have an outsized impact on the emission estimate. Emission rate distributions frequently have a positive skew and potentially a fat tail, which could result in a relatively small number of high emitting sources/sites accounting for a disproportionate fraction of emissions. Consequently, estimates based on a limited sample of measurements can bias low, since they are statistically more likely to exclude these highest emitting sites.

The following Matrix 1 offers a starting point, to approach developing a sampling strategy for populations of sources and/or sites/facilities.

i) Operators should focus their most robust measurement efforts on reducing uncertainty associated with larger emissions.

ii) Each box in the sampling matrix has been divided between populations of sites/facilities with low (blue) or high (red) contribution to an asset's materiality.

iii) Simple and complex[12] sites/facilities require different amounts of sampling because simple sites/facilities are expected to have low variability in emissions and complex sites/facilities are expected to have higher variability, thus requiring a larger number of samples to fully characterize the time-variation in emissions. Sampling for sources should be treated as simple.

For example, a population of valves or even simple production sites with fewer sources would require fewer measurement samples to characterize compared to a population of complex central tank batteries. Similarly, pipe segments, meter runs, and pressure regulating stations are likely simple. The sampling recommendations are provided in terms of the percentage of the total population that should be sampled. Directionally, as a population size increases, a smaller percentage of the sites will require measurement, though the absolute number of facilities may increase. Selection of sampling size should consider technical, time and resource constraints. Sampling strategy may include data from mutual studies across companies, provided they comprise like-systems as part of a representative sample clustering information from similar assets and conveyed volumes.

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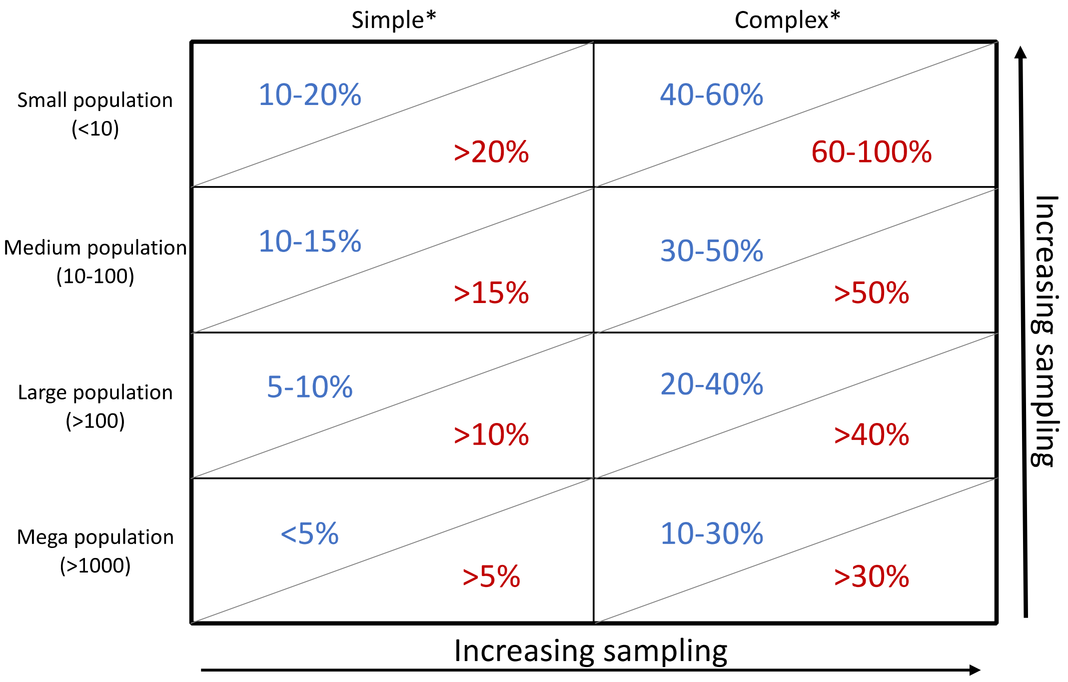
[12] Complexity in terms of emissions distribution or site/infrastructure typology (e.g., simple: single well-head production site, segments of pipeline in a distribution system, complex: central processing facilities, compressor stations)

Matrix 1: Starting point guidance to establish percentages of the of sites/facilities/sources for sampling plans where there is a population of sites/facilities and/or sources.
Blue – Low contribution of materiality[13] of emissions,
Red – High Contribution to materiality of emissions,
Complexity in terms of emissions distribution or site/infrastructure typology
Simple and Complex categorization should be applied to define sampling population for site level measurements. For source-level quantification virtually all sources will fall within Simple category



	Simple*	Complex*
Small population (<10)	10-20% >20%	40-60% 60-100%
Medium population (10-100)	10-15% >15%	30-50% >50%
Large population (>100)	5-10% >10%	20-40% >40%
Mega population (>1000)	<5% >5%	10-30% >30%

Like measurement frequency for site-level measurements, population sampling should be dictated using a risk-based approach. Operating units where the data suggest that there are large uncertainties in emissions, and/or where the absolute emissions level (or risk of significant, unidentified emissions) are large, should be candidates for larger measurement campaigns.

It is hypothesized that a snapshot of emissions over a population of similar sites would yield similar emissions distributions to taking a similar number of emissions measurements over time at an individual site. Judgment should be used to ensure representative sampling and provide justification for the chosen approach, which may vary between assets.

Companies may propose their own statistical approach considering the assets characteristics, complexity, and any other particularity. The statistical approach should be appropriate to match the emissions distribution with the best information available. They are also responsible to propose the frequency of measurements throughout the reporting year based on the variability of asset-wide operations or source-specific characteristics. In those cases where a company can

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demonstrate that site-level measurement has been conducted for a statistically representative sample of similar population[14] (within one asset over time or across many assets), all relevant assets may claim reporting at Level 5 for that reporting year.

Practical considerations to proceed:

- Understanding the expected distribution of emissions for a population of sources or sites is important for assessment of uncertainty. The appropriate standard statistical methods that will be applied to estimate uncertainty are selected based upon the shape of this distribution (e.g., normal, skewed).
- Sampling strategies for both source-level and site-level should consider that emissions likely follow complex profiles, including potential fat tailed and skewed distributions
- The progressive goal of the reconciliation should be ensuring the completeness of emissions reporting and increasing confidence in emissions reports
- Know-how will be built up as operators share experience of measurement and reconciliation as well as with development of emerging techniques

Source- and site-level measurements can be mutually informative, but must be performed independently (using independent methods/technologies). While one can inform the strategy/approach of the other, a single measurement campaign cannot satisfy both the requirement for source- and site-level measurement.

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[14] See sections 3 and 4 below regarding defining of population and sampling strategy

5 Uncertainty & Reconciliation

A key hurdle for managing methane emissions is gaining consensus on the specific quantity and distribution, given the high uncertainty associated with traditional methods to quantify methane emissions. Progression from one reporting level to the next requires an increasing comprehensiveness in terms of emission source granularity, methodological rigor in quantification, and reduced uncertainty in the reported figures. An understanding of uncertainty and the contribution of different components is the basis upon which efforts to reduce emissions can be demonstrated with confidence.

The uncertainty of reported emissions should be stated as a value accompanied by a confidence interval (e.g. two standard deviations or 95%). This uncertainty is estimated through propagation of all potential sources of error for the reported emissions and should follow standard protocols. A variety of literature and resources are available to aid in mathematical approaches to estimate uncertainty (cf. 'References' section).15,16

As part of the L5 reporting process, operators should provide information on:

- Justification of the selected method (ideally independent validation of method where possible). Other methodologies than the ones included in this document can be used by the operators.
- The steps required to derive mass emission data, including all required ancillary data and calculation steps. This could be handled through an example calculation
- If more than one measurement was performed, and independently of the outcome of the reconciliation process (i.e, convergence/divergence of source-level and site-level estimates), report all individual measurements either for single sites or population of sites.

Reconciliation should be carried out between emissions data which have been determined on the same basis, particularly in terms of the spatial coverage and the time frame, i.e. emissions data should be reconciled which cover the same sources and which are representative of the same time period. The uncertainties which are associated with these data should have been calculated for the reported values – for example if reconciliation is done on annual emission data, the uncertainty should have been calculated for this annual value.

Reconciliation requires an estimate of uncertainty for both L4 estimates and site level measurements. Most importantly, the uncertainty of source- and site-level measurement should be chosen in such a way that a comparison makes sense. Ideally, L5 reported emissions would be

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[15] The basis and concepts for deriving and reporting measurement uncertainties are described in the guide to the expression of uncertainty, commonly known as the GUM (Evaluation of measurement data – Guide to the expression of uncertainty in measurement, JCGM 100:2008 which is also published as ISO/IEC Guide 98-3:2008, and associated annexes.)

[16] It is recommended to use international standardised methods such as those produced by ISO or regional standardisation bodies where available, otherwise national methods or those recognised by industry bodies should be used. Where no such methods exist, measurements should at the least follow controlled written procedures and evidence of independent validation should be requested. The use of measurement providers who are accredited to carry out measurements to a recognised quality standard such as ISO 17025 can provide additional assurance.

derived where there is agreement between uncertainties of the two. To the extent there is no agreement between the sum of source-level estimates and site-level measurements, an operator should endeavor to understand the source of disagreement and incorporate any adjustment (increase or decrease as appropriate) to the asset level (L5) reported value. This could also result in a subsequent revision to the source- or site-level method identified to cause over- or underestimation of emissions.

Generally, greater measurement sampling results in uncertainty reduction. It can be costly to reduce uncertainty on estimated methane emissions, either in terms of measurement frequency or sampling size from a population. Decisions on reducing uncertainty should be fit for purpose – balancing between resources deployed and where uncertainty reductions have the largest potential to materially change the emissions reported for a given asset. Operators should apply judgement and focus on reducing uncertainty where it matters most – where emissions are material and the remaining uncertainty, itself, is material. For example, reducing an uncertainty of ±50% for a source that constitutes 0.1% of emission at an asset will not discernably change the resultant reported emission. Conversely, lowering uncertainty of ±30% for a source that constitutes 40% of emissions at an asset could be quite material.

6. References

Additional references to support reconciliation and uncertainty have been compiled here, pertaining to methane studies, detection technologies, sampling, and uncertainty.

METHANE
GUIDING
PRINCIPLES

Reducing Methane Emissions:
Best Practice Guide
Identification, Detection,
Measurement and Quantification

September 2020

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3. JCGM-200. International vocabulary of metrology – Basic and general concepts and associated terms (VIM) 3rd edition 2008
4. Marcogaz: Methane Emissions Glossary, 1st of april 2021
5. Guidance on Uncertainty Analysis in Scientific Assessments - EFSA
6. AUDITING ACCOUNTING ESTIMATES, INCLUDING FAIR VALUE ACCOUNTING ESTIMATES, AND RELATED DISCLOSURES - IFAC
7. MATERIALITY IN PLANNING AND PERFORMINGAN AUDIT - International Standard on Auditing
8. Guidance/best practices on materiality and sampling pursuant to Regulation (EU) 2015/757
9. The Monitoring and Reporting Regulation – Guidance on Sampling and Analysis - EC DGCA
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17. Mid-continent basin - methane emissions reconciliation: facility level emissions https://mountainscholar.org/handle/10217/190076
18. Anna M. Robertson, et. al. Variation in Methane Emission Rates from Well Pads in Four Oil and Gas Basins with Contrasting Production Volumes and Compositions. *Environ. Sci. Technol.* **2017,** *51*, 15, 8832–8840. https://doi.org/10.1021/acs.est.7b00571
19. Temporal variability largely explains top-down/bottom-up difference in methane emission estimates from a natural gas production region https://doi.org/10.1073/pnas.1805687115
20. Constructing a Spatially Resolved Methane Emission Inventory for the Barnett Shale Region *Environ. Sci. Technol.* 2015, 49, 13, 8147–8157 https://doi.org/10.1021/es506359c
21. Spatial and temporal emissions variability from upstream and midstream sources in the Eagle Ford Oil and Gas production region https://repositories.lib.utexas.edu/handle/2152/61655
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