

# Converting Measurements Into Measurement Informed Inventories: Lessons from Cheniere's QMRV Research Series



Global Methane Initiative, Geneva

March 20, 2024



# Safe Harbor Statements

## Forward-Looking Statements

This presentation contains certain statements that are, or may be deemed to be, “forward-looking statements” within the meaning of Section 27A of the Securities Act of 1933, as amended, and Section 21E of the Securities Exchange Act of 1934, as amended. All statements, other than statements of historical or present facts or conditions, included or incorporated by reference herein are “forward-looking statements.” Included among “forward-looking statements” are, among other things:

- statements regarding the ability of Cheniere Energy Partners, L.P. to pay or increase distributions to its unitholders or Cheniere Energy, Inc. to pay or increase dividends to its shareholders or participate in share or unit buybacks;
- statements regarding Cheniere Energy, Inc.’s or Cheniere Energy Partners, L.P.’s expected receipt of cash distributions from their respective subsidiaries;
- statements that Cheniere Energy Partners, L.P. expects to commence or complete construction of its proposed liquefied natural gas (“LNG”) terminals, liquefaction facilities, pipeline facilities or other projects, or any expansions or portions thereof, by certain dates or at all;
- statements that Cheniere Energy, Inc. expects to commence or complete construction of its proposed LNG terminals, liquefaction facilities, pipeline facilities or other projects, or any expansions or portions thereof, by certain dates or at all;
- statements regarding future levels of domestic and international natural gas production, supply or consumption or future levels of LNG imports into or exports from North America and other countries worldwide, or purchases of natural gas, regardless of the source of such information, or the transportation or other infrastructure, or demand for and prices related to natural gas, LNG or other hydrocarbon products;
- statements regarding any financing transactions or arrangements, or ability to enter into such transactions;
- statements relating to Cheniere’s capital deployment, including intent, ability, extent, and timing of capital expenditures, debt repayment, dividends, share repurchases and execution on the capital allocation plan;
- statements regarding our future sources of liquidity and cash requirements;
- statements relating to the construction of our proposed liquefaction facilities and natural gas liquefaction trains (“Trains”) and the construction of our pipelines, including statements concerning the engagement of any engineering, procurement and construction (“EPC”) contractor or other contractor and the anticipated terms and provisions of any agreement with any EPC or other contractor, and anticipated costs related thereto;
- statements regarding any agreement to be entered into or performed substantially in the future, including any revenues anticipated to be received and the anticipated timing thereof, and statements regarding the amounts of total LNG regasification, natural gas, liquefaction or storage capacities that are, or may become, subject to contracts;
- statements regarding counterparties to our commercial contracts, construction contracts and other contracts;

- statements regarding our planned development and construction of additional Trains or pipelines, including the financing of such Trains or pipelines;
- statements that our Trains, when completed, will have certain characteristics, including amounts of liquefaction capacities;
- statements regarding our business strategy, our strengths, our business and operation plans or any other plans, forecasts, projections or objectives, including anticipated revenues, capital expenditures, maintenance and operating costs, free cash flow, run rate SG&A estimates, cash flows, EBITDA, Consolidated Adjusted EBITDA, distributable cash flow, distributable cash flow per share and unit, deconsolidated debt outstanding, and deconsolidated contracted EBITDA, any or all of which are subject to change;
- statements regarding projections of revenues, expenses, earnings or losses, working capital or other financial items;
- statements regarding legislative, governmental, regulatory, administrative or other public body actions, approvals, requirements, permits, applications, filings, investigations, proceedings or decisions;
- statements regarding our anticipated LNG and natural gas marketing activities; and
- any other statements that relate to non-historical or future information.

These forward-looking statements are often identified by the use of terms and phrases such as “achieve,” “anticipate,” “believe,” “contemplate,” “continue,” “could,” “develop,” “estimate,” “example,” “expect,” “forecast,” “goals,” “guidance,” “intend,” “may,” “opportunities,” “plan,” “potential,” “predict,” “project,” “propose,” “pursue,” “should,” “subject to,” “strategy,” “target,” “will,” and similar terms and phrases, or by use of future tense. Although we believe that the expectations reflected in these forward-looking statements are reasonable, they do involve assumptions, risks and uncertainties, and these expectations may prove to be incorrect. You should not place undue reliance on these forward-looking statements, which speak only as of the date of this presentation. Our actual results could differ materially from those anticipated in these forward-looking statements as a result of a variety of factors, including those discussed in “Risk Factors” in the Cheniere Energy, Inc. and Cheniere Energy Partners, L.P. Annual Reports on Form 10-K filed with the SEC on February 22, 2024, which are incorporated by reference into this presentation. All forward-looking statements attributable to us or persons acting on our behalf are expressly qualified in their entirety by these “Risk Factors.” These forward-looking statements are made as of the date of this presentation, and other than as required by law, we undertake no obligation to update or revise any forward-looking statement or provide reasons why actual results may differ, whether as a result of new information, future events or otherwise.

# Market-Leading LNG Platform with Global Scale



**#2**  
SECOND LARGEST LIQUEFACTION  
PLATFORM GLOBALLY



**~8%**  
OF US NATURAL GAS PRODUCTION  
PROCESSED DAILY AT SPL & CCL



**~3,280**  
CARGOES EXPORTED FROM  
CHENIERE PROJECTS



**>\$40B**  
INVESTMENT IN  
INFRASTRUCTURE<sup>(1)</sup>



**11%+**  
OF GLOBAL LIQUEFACTION  
CAPACITY



**39**  
COUNTRIES & REGIONS  
DELIVERED TO FROM CHENIERE



**#1**  
LNG PROVIDER TO EUROPE  
IN 2022 & 2023



**#122**  
2023 Fortune 500

## Sabine Pass Liquefaction

~30 mtpa Total Production Capacity



## Corpus Christi Liquefaction

~25+ mtpa Total Production Capacity<sup>(1)</sup>



## > 30 Creditworthy Counterparties Across the Globe



## Leading EPC and Infrastructure Providers



# Cheniere Climate & Sustainability Initiatives

Climate Strategy Focus: Evidence-based science, operations excellence and transparent collaboration

**APRIL 2021**

Climate Scenario Analysis



**JUNE 2021**

QMRV Collaboration (Upstream)



**AUGUST 2021**

Life Cycle Assessment



**APRIL 2022**

QMRV Collaboration (Midstream)



**JUNE 2022**

QMRV Collaboration (Liquefaction)



**JUNE 2022**

Cargo Emissions Tags



**OCTOBER 2022**

OGMP 2.0



**JANUARY 2023**

Energy Emissions Modelling & Data Lab



# QMRV – Improving Data through Measurement

## UPSTREAM

Collaboration with 5 natural gas producers across 3 basins utilizing ground-based, drone, aerial, and satellite monitoring technologies



## SHIPPING

First-of-its-kind study to directly measure methane emissions of an operating LNG vessel



## MIDSTREAM

Collaboration with pipelines, compressor stations, gathering & boosting, processing & storage facilities



Gillis Compressor Station  
Pilot Project for Midstream QMRV



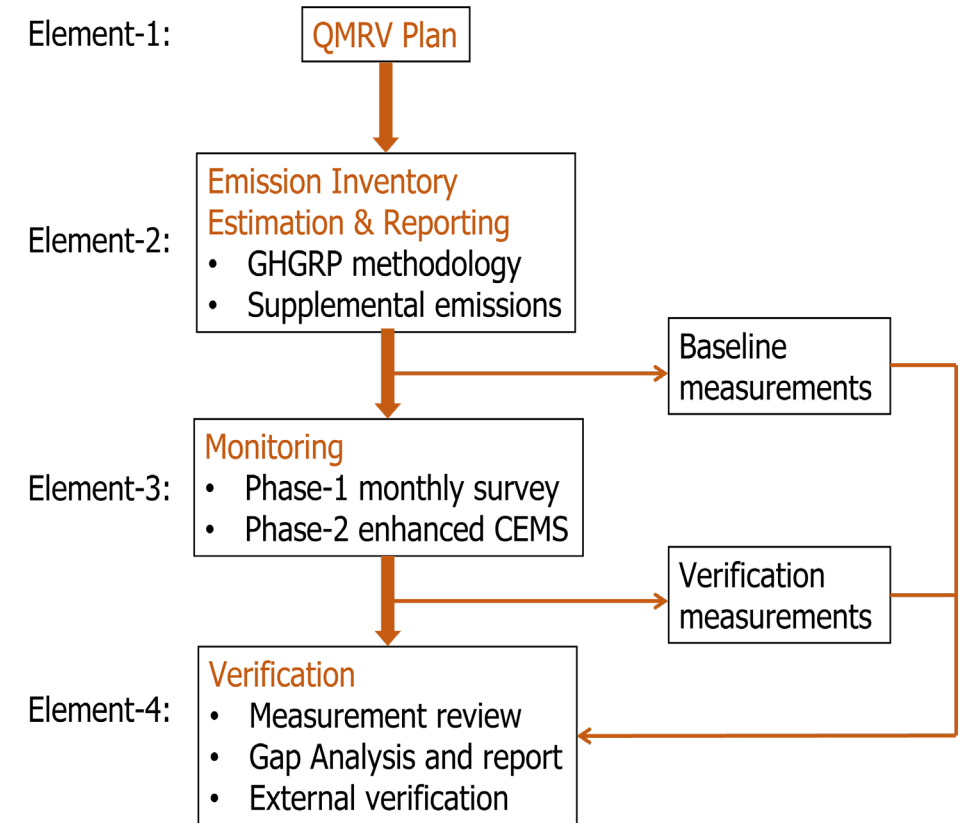
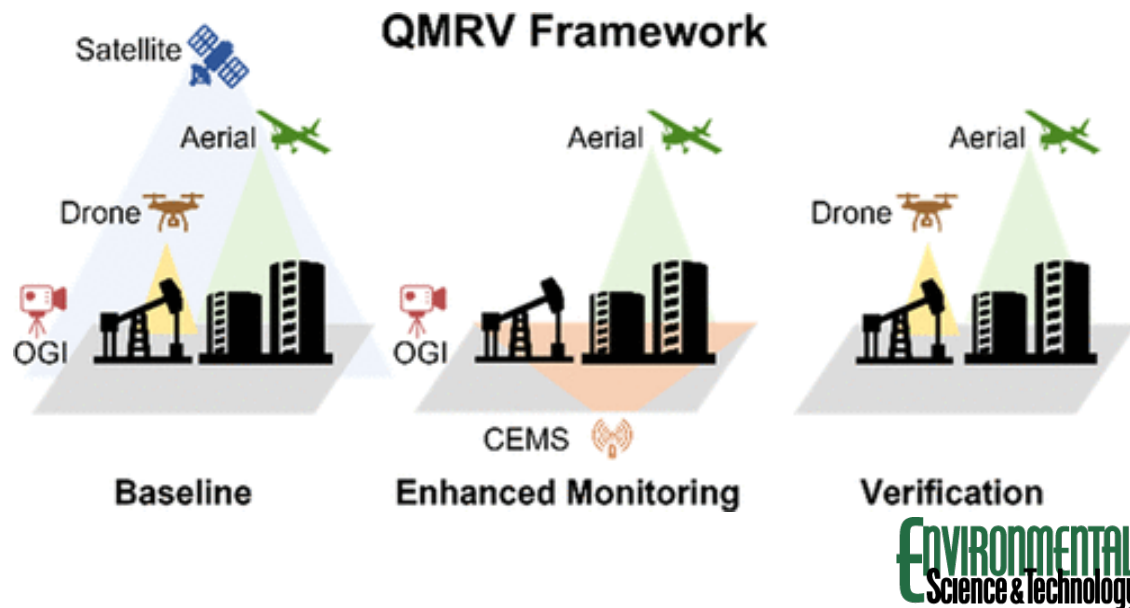
## LIQUEFACTION

Aerial and ground-based measurements at SPL and CCL



# QMRV R&D Program Framework

- ❑ The QMRV protocol consists of multi-scale and contemporaneous whole facility CH<sub>4</sub> measurements conducted by an **independent scientific team**.
- ❑ The participants tested a protocol developed by O&G and GHG measurement experts, aiming to understand how measured emissions compare to traditional inventories.



# QMRV R&D Research Publications

- The findings of the QMRV R&D Program are published in peer-reviewed journals

## Multiscale Methane Measurements at Oil and Gas Facilities Reveal Necessary Frameworks for Improved Emissions Accounting

Jiayang Lyra Wang, William S. Daniels, Dorit M. Hammerling, Matthew Harrison, Kaylyn Burmaster, Fiji C. George, and Arvind P. Ravikumar  
Publication Date: October 6, 2022



## Toward Multiscale Measurement-Informed Methane Inventories: Reconciling Bottom-Up Site-Level Inventories with Top-Down Measurements Using Continuous Monitoring Systems

William S. Daniels, Jiayang Lyra Wang, Arvind P. Ravikumar, Matthew Harrison, Selina A. Roman-White, Fiji C. George, and Dorit M. Hammerling  
Publication Date: July 28, 2023



## Informing Methane Emissions Inventories Using Facility Aerial Measurements at Midstream Natural Gas Facilities

Jenna A. Brown, Matthew R. Harrison, Teclé Rufael, Selina A. Roman-White, Gregory B. Ross, Fiji C. George, and Daniel Zimmerle  
Publication Date: August 29, 2023



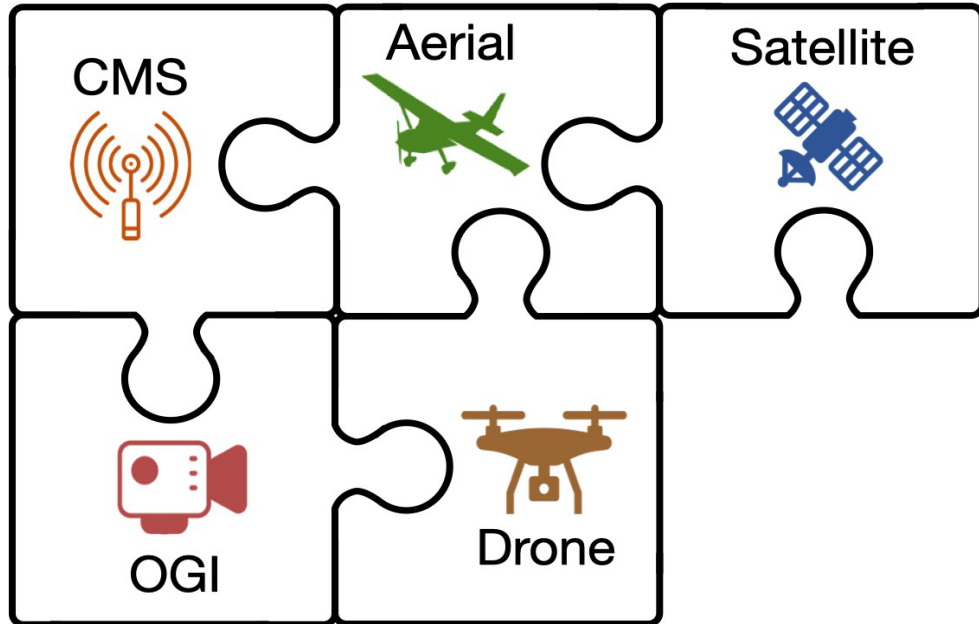
## Evaluating development of empirical estimates using two top-down methods at midstream natural gas facilities

Jenna A. Brown, Matthew R. Harrison, Gregory B. Ross, Fiji C. George, Teclé Rufael, Selina A. Roman-White, and Daniel Zimmerle  
Pre-print Date: October 12, 2023



<https://doi.org/10.26434/chemrxiv-2023-9j9ht>

# QMRV R&D Findings



Multi-scale measurements are complementary

- OGI-based surveys along can not identify all methane emission sources at complex facilities
- Compliment ground-based measurement technologies, including continuous monitoring systems, stack and fugitive emissions measurements with aerial and satellite measurements



CH<sub>4</sub> measurements are frequently, though not always, higher than operator-estimated inventories



Natural gas facilities across all segments of the value chain show significant temporal variability



CH<sub>4</sub> Emissions at midstream and downstream (large) facilities are more difficult to estimate and are driven by the operational configuration of each facility



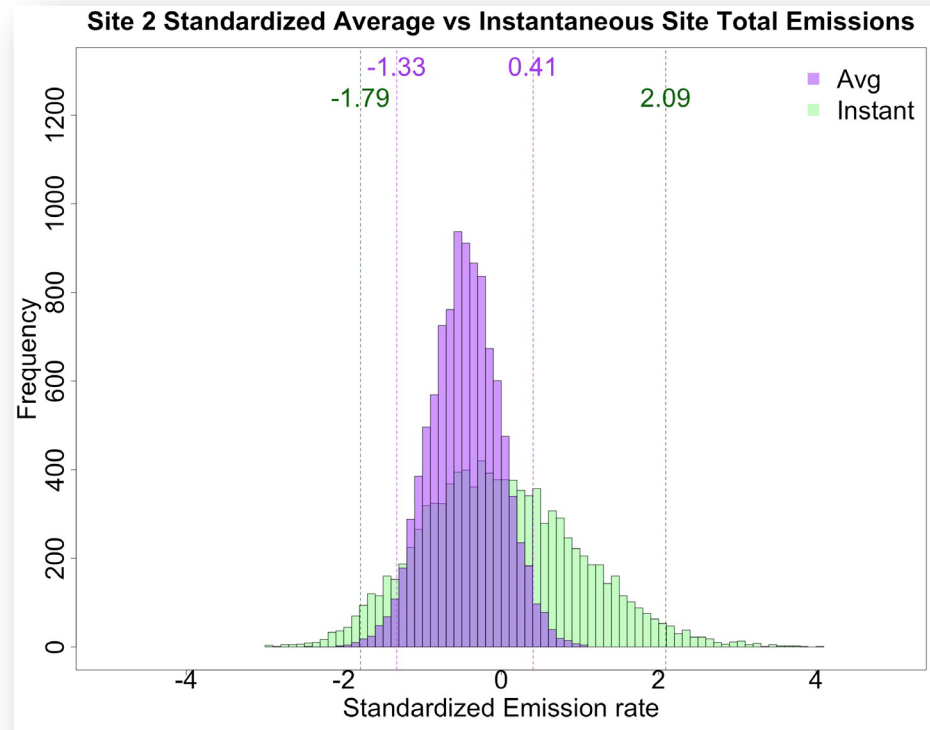
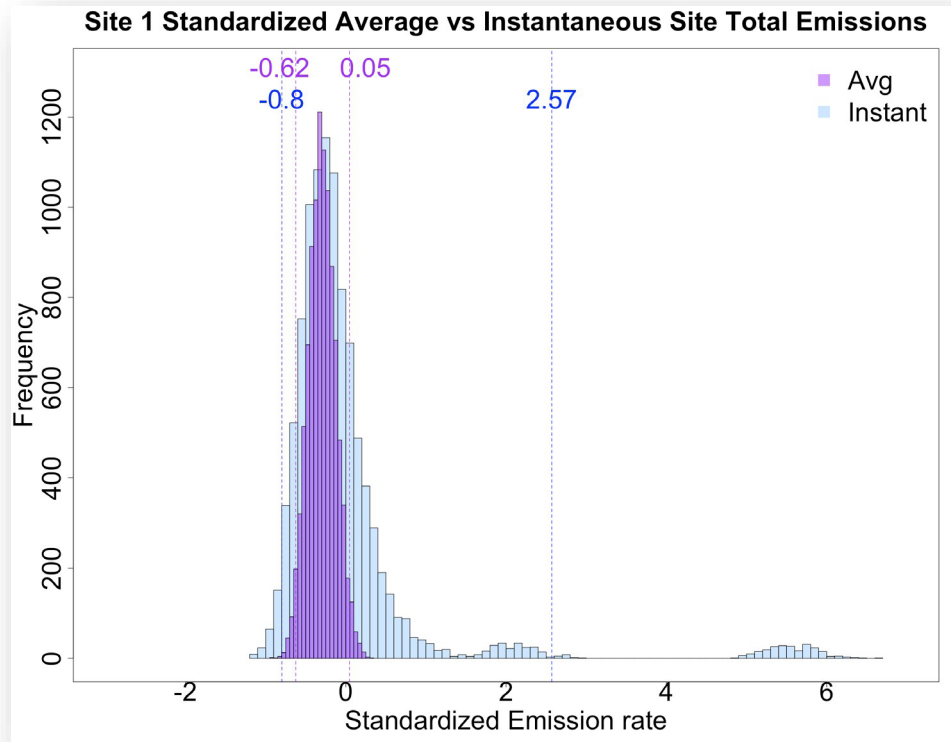
Operator participation and data collection is essential for mitigation



Multi-scale and frequent measurements enable remedial actions to be taken by operators faster, and measurement informed inventories (MIIs) can help operators prioritize efforts to reduce facility GHG emissions



# Instantaneous Versus Average Site Methane Emissions



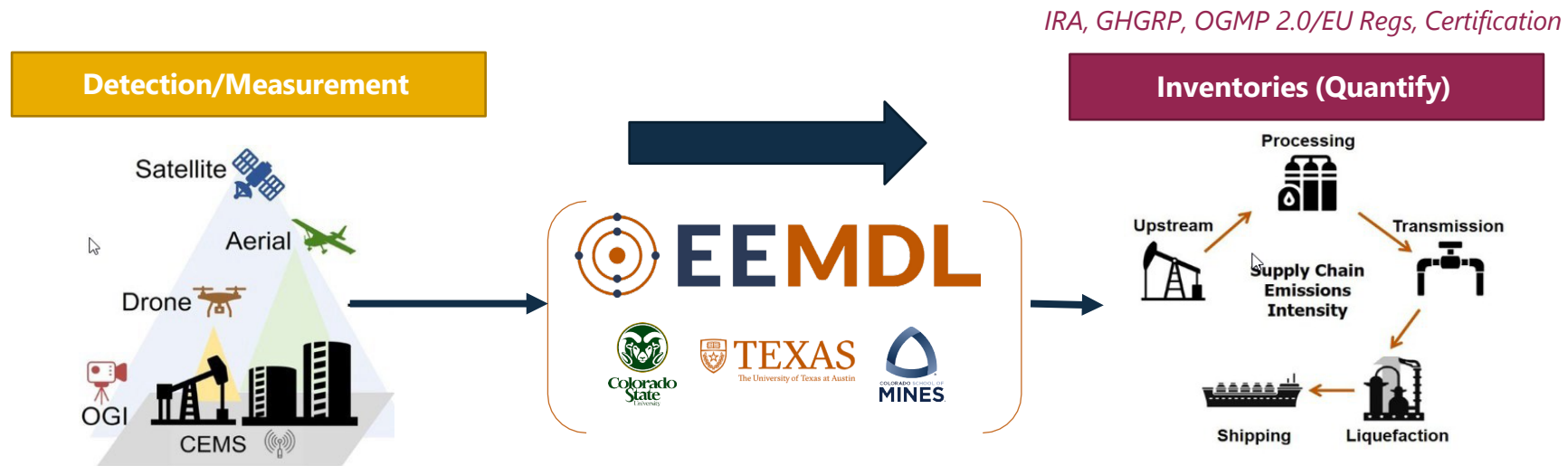
\*Source: Khaliukova et al. (2023). Poster presentation at EEMDL Annual Conference

Emission rates (x-axis) were standardized preserving the shapes and corresponding relationship of the distribution profiles. Distribution profiles do not represent actual emission rates

- While the means of the two distributions were found to be similar for both sites, the potential site total at a given moment in time could be larger or smaller than the site total found using the averaging approach.

➔ important when reconciling annual average estimate and L4/L5 emissions

# The Scientific Community is Essential for Translating Measurements Into Inventories



**Consortium of world-renowned academic experts who have conducted measurement campaigns at 2,000+ sites and published over two dozen peer reviewed papers over the past decade**



**30+ person research staff consisting of academics, post-docs, full-time staff, graduate students and undergraduates to support EEMDL's work products**



**Technical and Strategic Advisory Committees to ensure work products are relevant to key policy stakeholders**



**Work collaboratively with regulators, NGOs and industry to incorporate best available data into analysis**

# Framework for Customized Life Cycle GHG Assessments for LNG Supplies

ACS Sustainable Chemistry & Engineering

pubs.acs.org/journal/ascecg



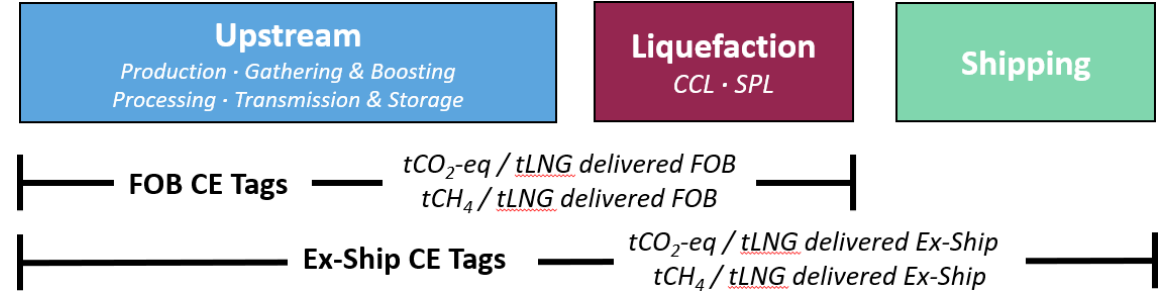
Research Article

## LNG Supply Chains: A Supplier-Specific Life-Cycle Assessment for Improved Emission Accounting

Selina A. Roman-White, James A. Littlefield, Kaitlyn G. Fleury, David T. Allen, Paul Balcombe, Katherine E. Konschnik, Jackson Ewing, Gregory B. Ross, and Fiji George\*

Cite This: <https://doi.org/10.1021/acssuschemeng.1c03307>

Read Online



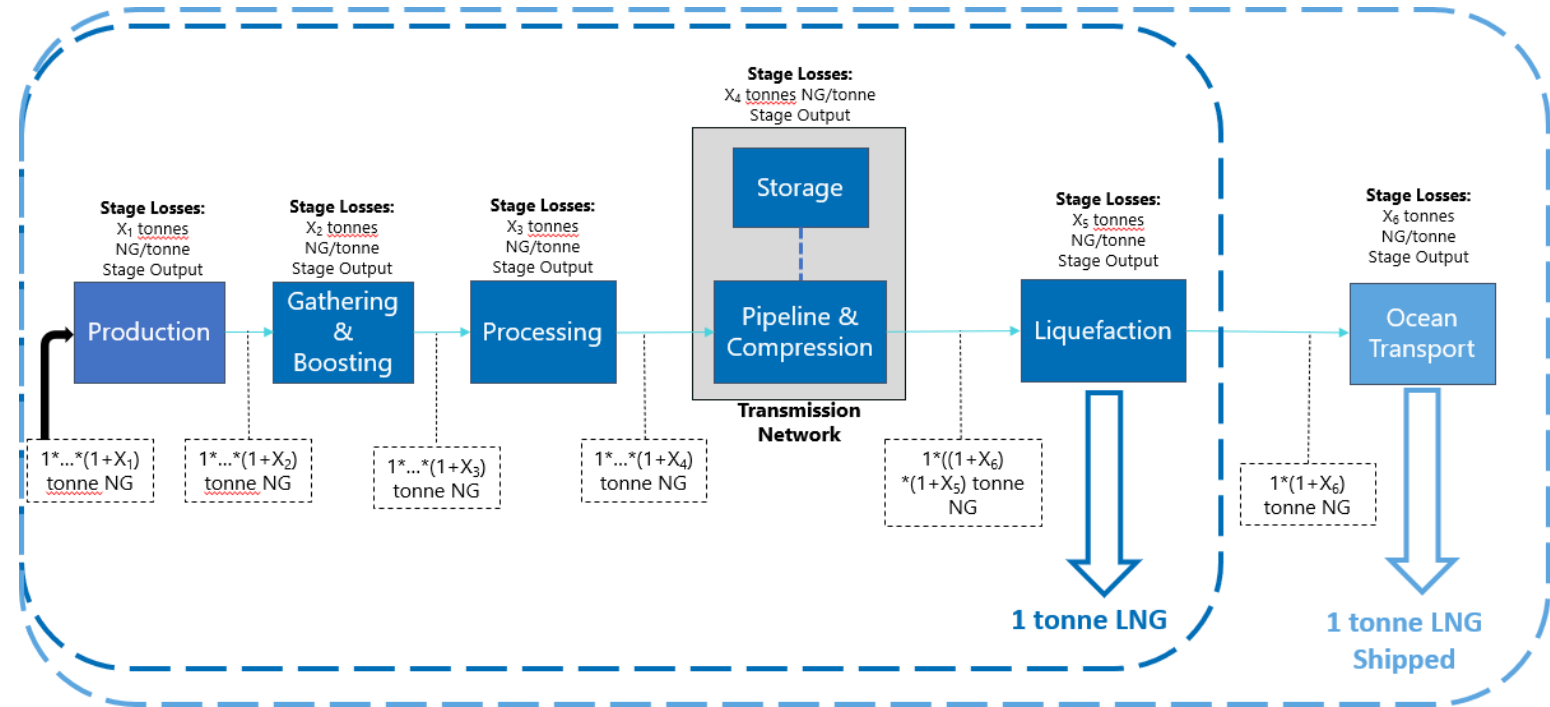
## Key Study Findings

National/regional average supply chains do not accurately represent unique supply chains

Supply chain emissions upstream of end use are significant

Characterizing the GHG intensity of specific gas supplies via LCAs is critical for informing differentiated gas supply, as well as policy & decision makers looking to develop climate strategies

Coal supply chains are also variable due to upstream methane emissions

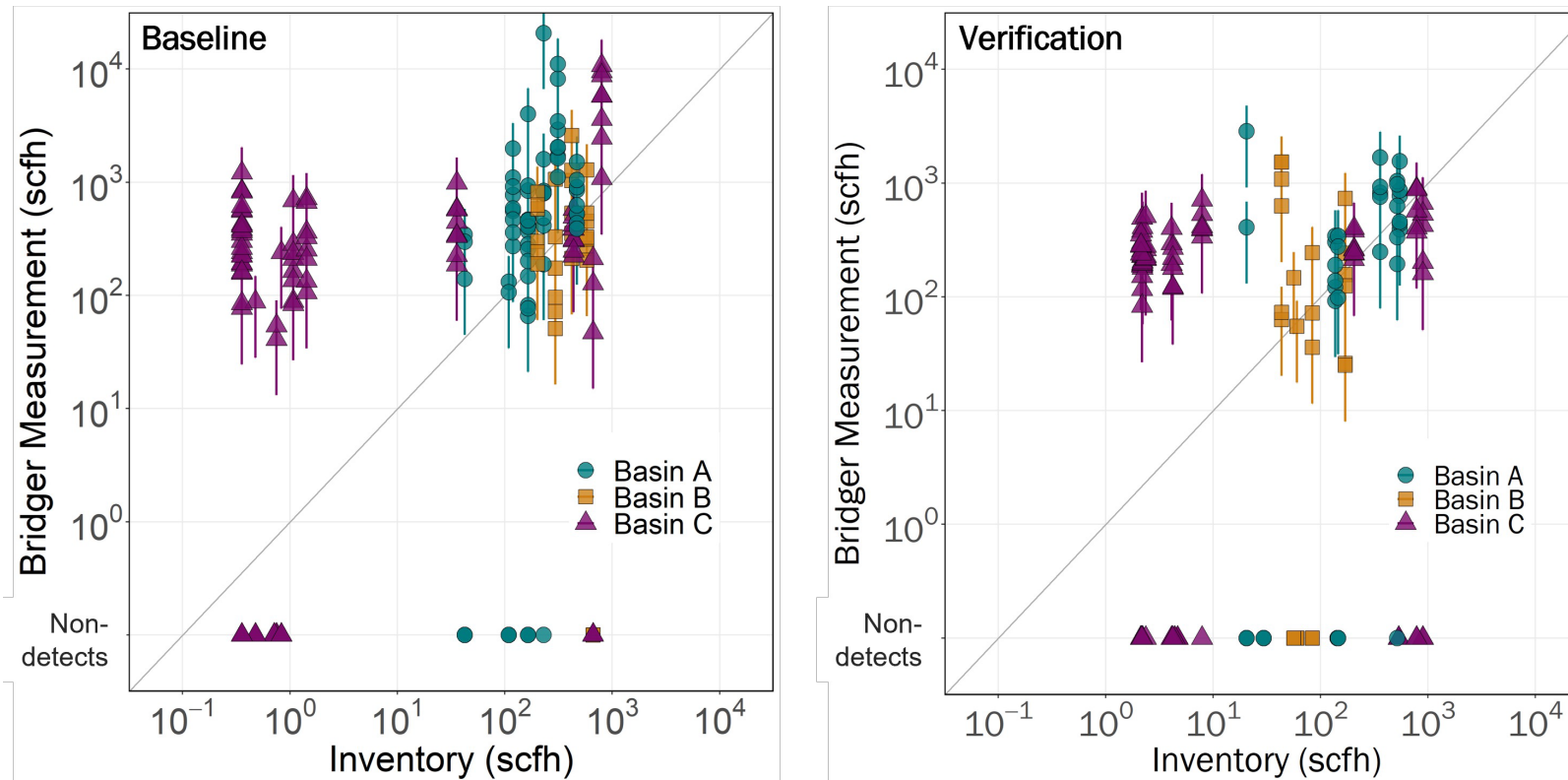


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# Thank you

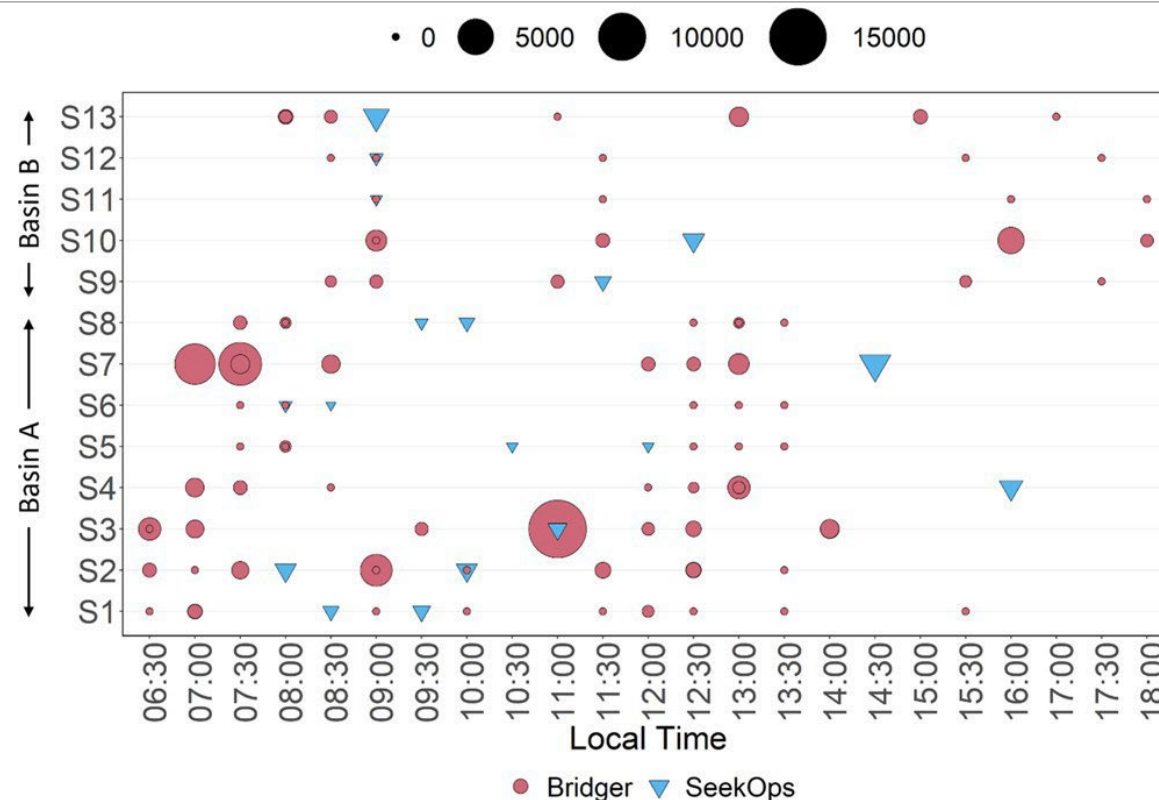
Questions?

# QMRV Finding 1: CH<sub>4</sub> Measurements are Frequently Higher than Operator-estimated Inventories



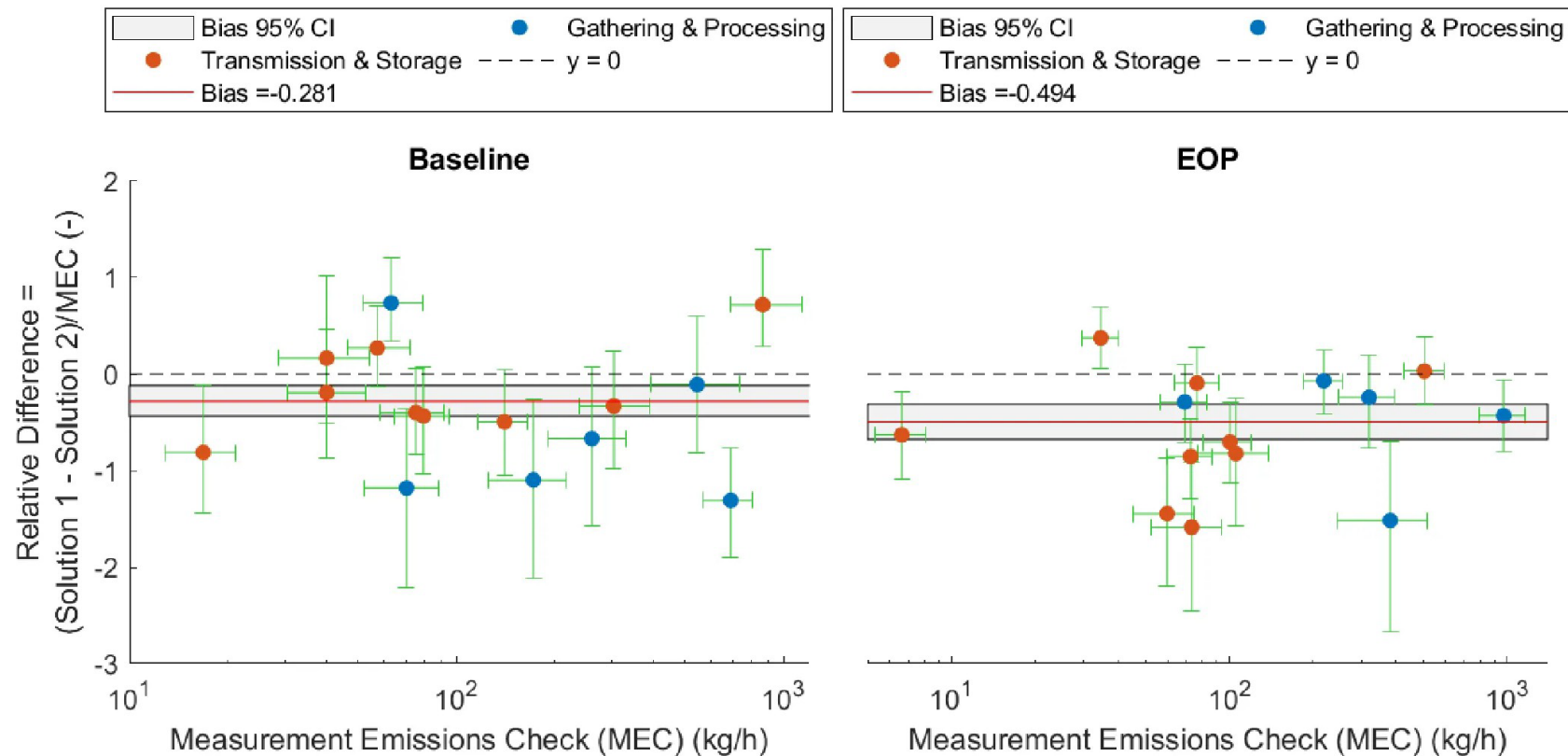
- ❑ Emissions vary across basins and operators (even within the same basin)
- ❑ Measurement Informed Inventories (MII) require **operator-specific, statistically representative emission factors** using direct measurements

# QMRV Finding 2: Temporal Variability in Natural Gas Facilities



- ❑ The histogram of CMS rate estimates over the 6-month monitoring period shows that the **2814 scfh Bridger measurement falls above the 99th percentile of all CMS rate estimates**, providing evidence that temporal variability and the snapshot nature of top-down measurements had a **large impact on the gap between bottom-up inventory and TDA** on this site

# QMRV Finding 3: Midstream and Large Facilities (Downstream) are Challenging



- ❑ Two technologies provided **persistent differences in methane emissions estimates**, even when multiple measurements were performed contemporaneously at a facility in a constant operating state

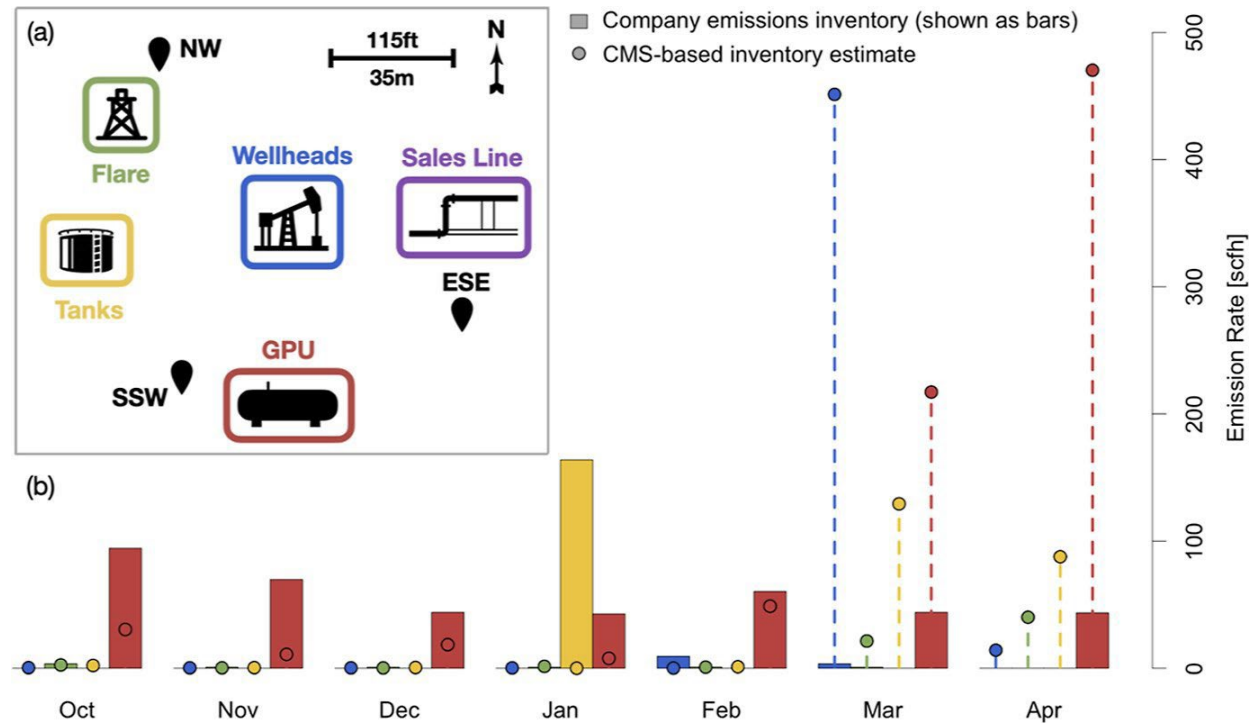
# QMRV Finding 4: Operator participation and Data Collection is Essential for Mitigation



- ❑ Operator engagement was crucial for understanding the facility emission profile. Operators provided context for what was happening at the site during the time of measurement. This is crucial for transforming measurements into measurement informed inventories.
- ❑ To best estimate a facility emissions profile over a longer time period, snapshot measurements must be paired with operations data to understand the representativeness of the measurements.
- ❑ Operators were best suited for ground truthing the measurements to inform actual emission mitigation.



# QMRV Finding 5a: Multi-scale and Frequent Measurements Enable Remedial Actions



- ❑ Case Study: Scientific team investigated a 94% gap between the bottom-up inventory and the end-of-project measurement (conducted in April).
- ❑ CMS data was analyzed to see if the emission source driving the gap could be confirmed, as well as give insight to temporal variability of the site
- ❑ CMS data showed a significant increase in estimated emissions from the GPU post-February. Operator had reported a GPU swap on Feb 23, 2022. The change in emissions from this swap was not captured in the bottom-up inventory, but had been caught by the CMS and top-down measurements

# QMRV Finding 5b: OGI-based Surveys Alone Can Not Identify All Methane Emissions Because of Complex Facility Structure

