Closing the gap: Explaining persistent underestimation of US oil and natural gas production methane inventories

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Different varieties of methane measurement inform our understanding of emissions quantities and sources

Bottom-up

Component-level

e.g., EPA Greenhouse Gas Inventory

Site-level

e.g., Alvarez et al. 2018, National estimate

Top-down

e.g., Zhang et al. 2020, Permian Basin

Policy and programs

Validation and assessment

The “top-down – bottom-up gap” has become a persistent thread in the literature

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Assessment of methane emissions from the U.S. oil and gas supply chain

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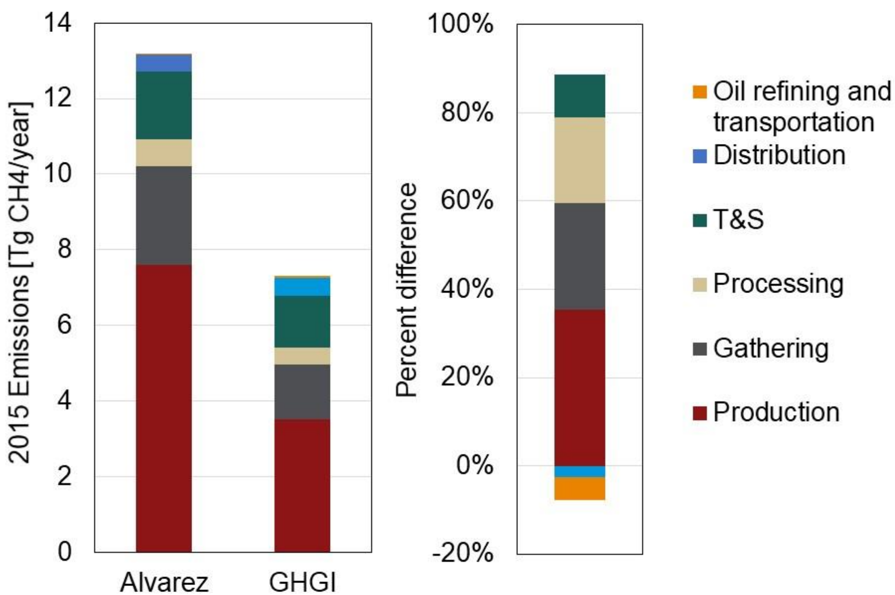

- Field studies at multiple scales consistently find higher emissions relative to the EPA Greenhouse Gas Inventory
- Alvarez et al. 2018 synthesized recent site-level measurement literature
- Largest discrepancy found in the production segment

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However, the literature has failed to identify why these gaps exist

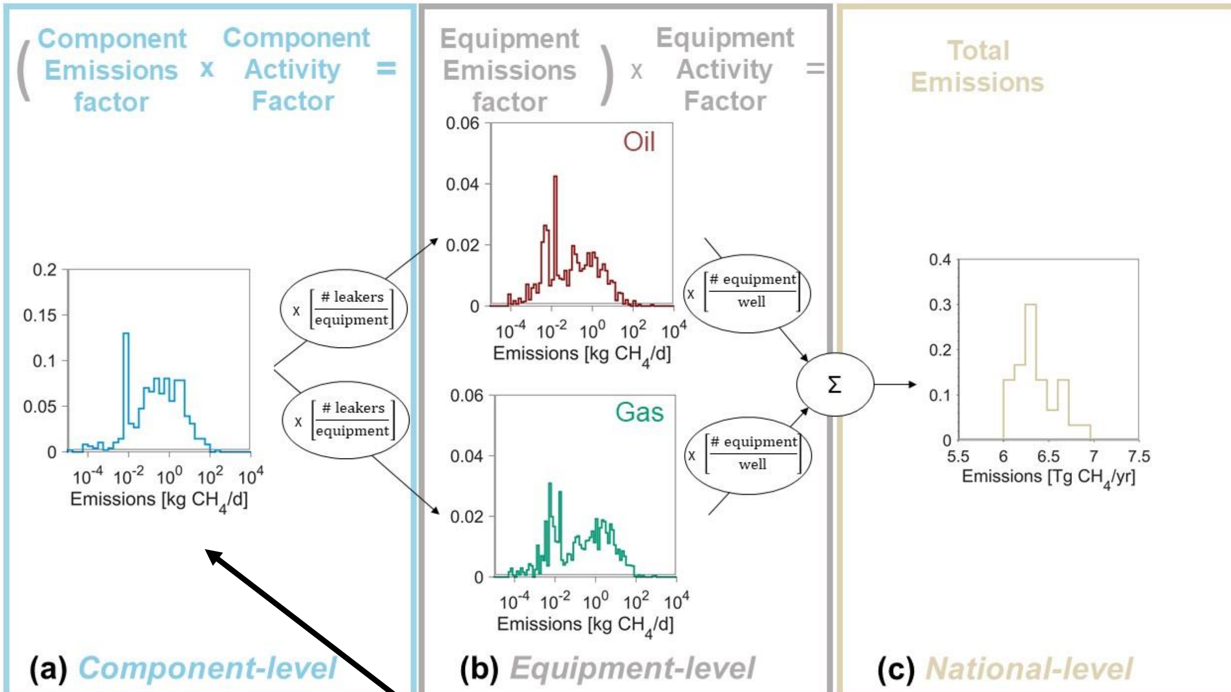
1. What is the root cause of the difference between these methods?
   - Missing super-emitters?
   - Inherent problems with BU methods?
   - Outdated data?
2. Can we build a BU inventory-based approach which matches TD and site level estimates?
   - We do not understand why there should be “inherent” problems with BU methods

These questions are important, because it is the bottom-up approaches which ultimately guide policy

Contributions of this study

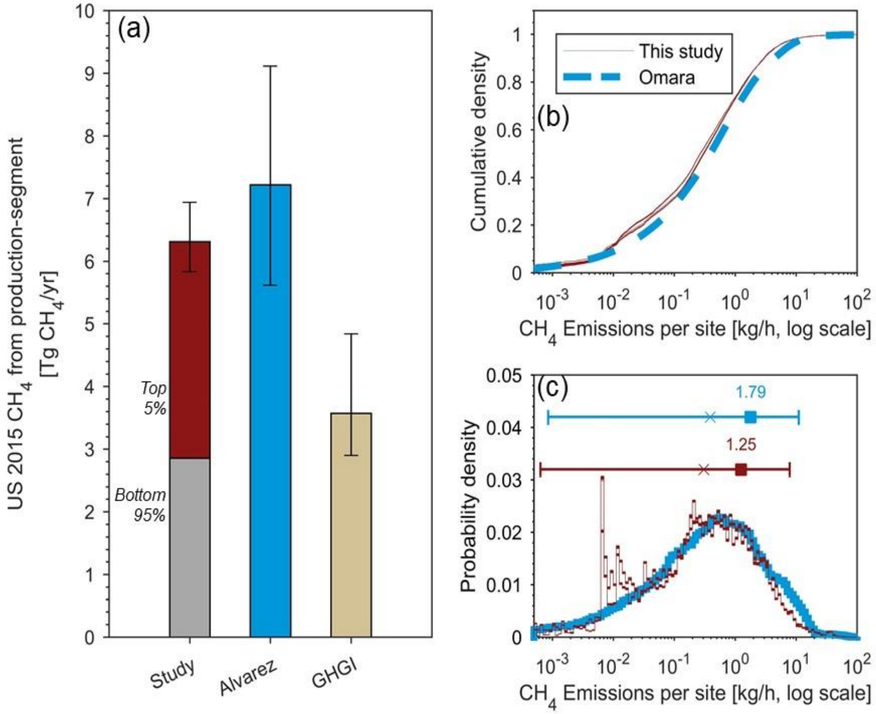
1. Development of a bottom-up methane emissions estimation tool
2. Estimate of US fossil-fuel **production-segment** methane emissions
3. Derivation of Greenhouse Gas Inventory emissions factors

Development of a bottom-up tool



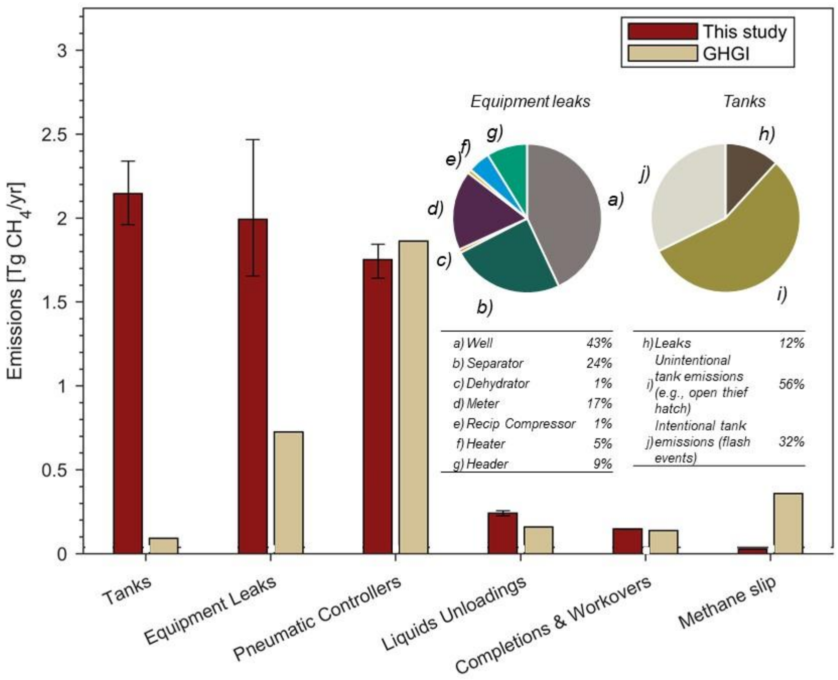
Informed by comprehensive literature search of component-level surveys (6 studies, ~3200 measurements)

Generating a US estimate of production-segment emissions



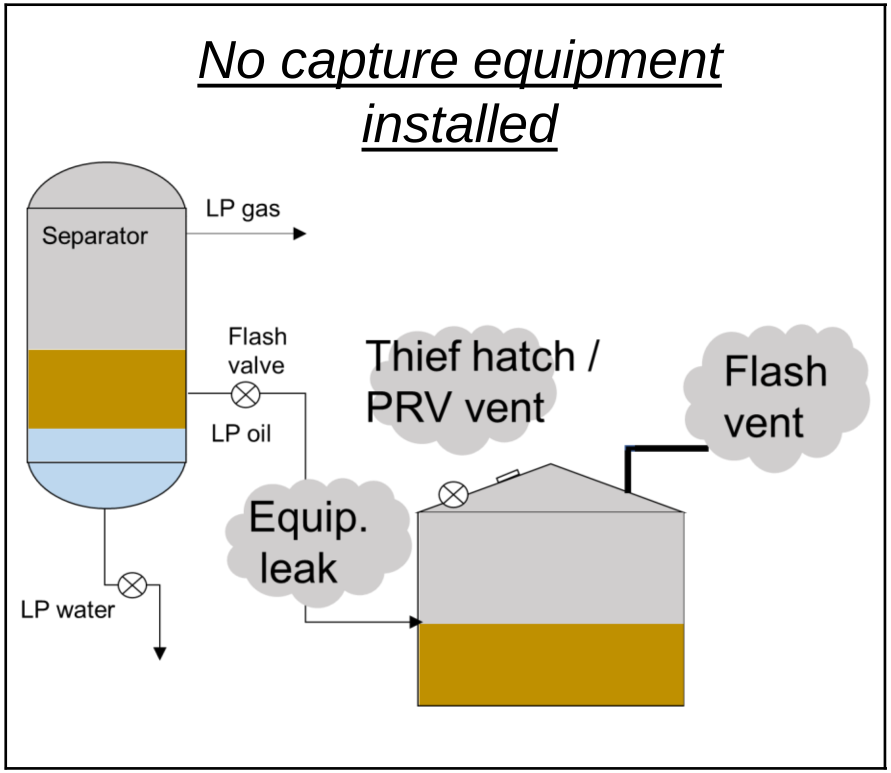
- **Validated with site-level studies**:
  - Total emissions – Alvarez et al. 2018
  - Probability distributions – Omara et al. 2018

US estimate of production-segment emissions by source



- **Largest discrepancies**:
  - (2.1 Tg CH_4) Tank flashing and venting emissions
  - (1.4 Tg CH_4) Equipment leaks

Tank emissions classification: Sources



Emissions mechanisms:

- Intentional vents at uncontrolled storage tanks: Flash gas from crude oil during dump events
- Thief hatch/ PRV vent: A wide range in emissions magnitudes are observed from open or malfunctioning thief hatches and PRV vents.
- Equipment leaks: Leaks observed on miscellaneous tank components

Evidence from aerial and ground surveys that thief hatches are a bigger problem

- **Lyon et al. (2016)**
  - A total of 494 unique high emissions sources were detected at 327 wells pads (4% of wellpads), with tank hatches and tank vents comprising 92% of observations
- **Mansfield et al. (2017)**
  - Even though the tanks were controlled, 196 plumes were observed at 178 wells (39% of well-pads). 79% of plumes were from thief hatches or pressure-relief valves.
- **Lyman et al. (2017)**
  - Well-pads with controlled tanks were more likely to have detected emissions compared to well-pads with uncontrolled tanks. According to Lyman et al., this was due to the fact that “most emissions were not from the control devices themselves, but from tank hatches, vents or piping upstream of control devices”.

Conclusions

- We developed a bottom-up approach validated, within uncertainty, by previous site-level estimates of US production-segment CH_4 emissions
- Our estimate is nearly 2 times that of the GHGI. This bias is largely driven by differences in equipment leaks and tank venting
- Recommendations based on this work:
  - Equipment leaks
    - Differences in equipment leakage emissions between our study and the GHGI are driven by higher component-level emissions factors.
  - Tank emissions
    - Our dataset suggests that both the frequency and magnitude of unintentional emissions from controlled and uncontrolled tanks (e.g., open thief hatches) are significant drivers of emissions

Works cited

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