Methane Emissions Insights from Technology Demonstration Projects

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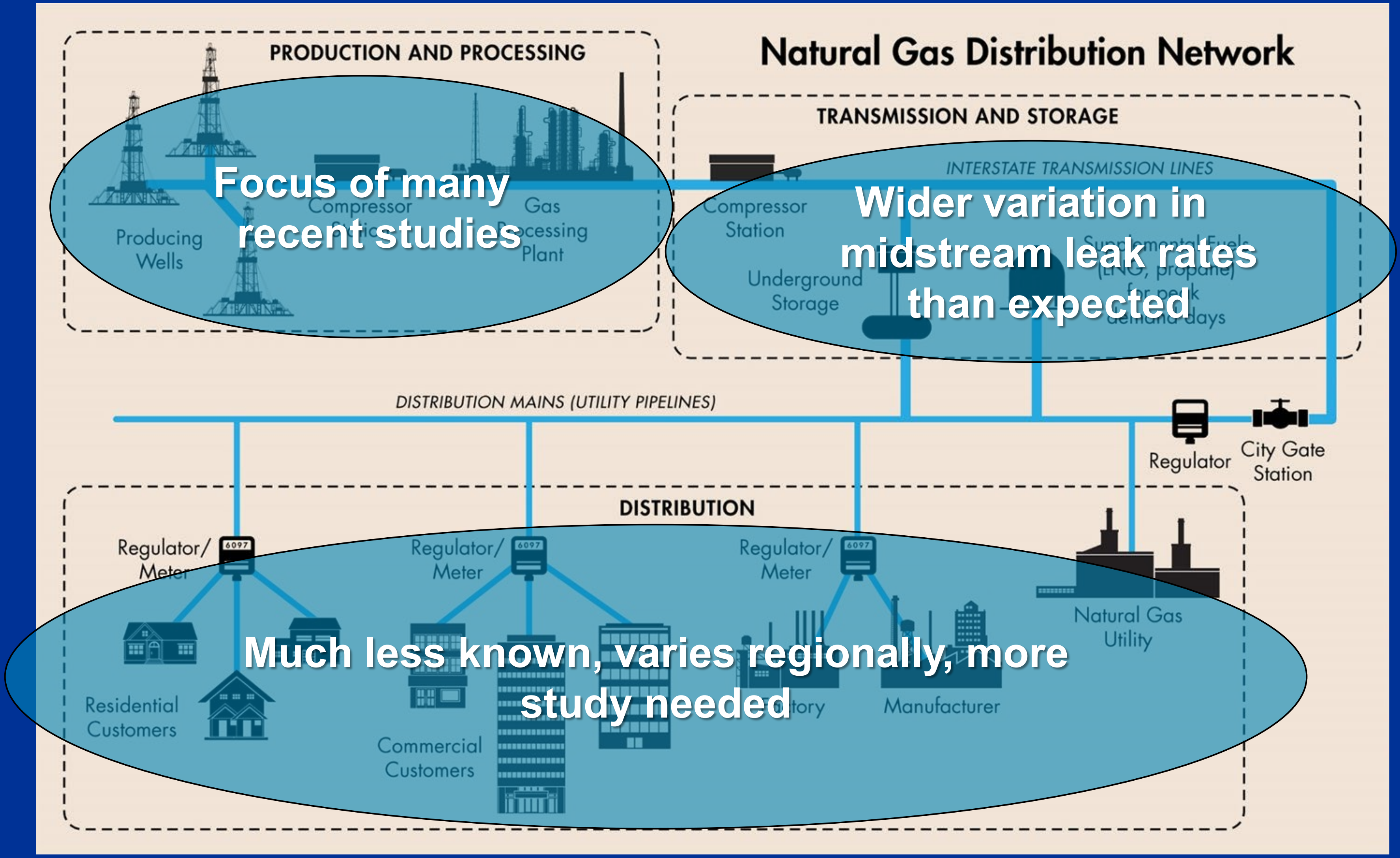
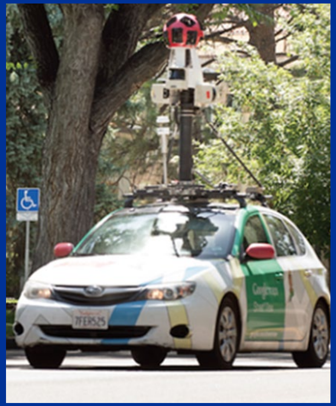
Methane Emissions Monitoring By Sector



Source	National-Level CH_4 Emissions (Gg/yr)
Natural Gas Power Plants	40–460
Metering & Regulating	42–313
Local Distribution Pipelines	197
Beyond-the-Meter Residential	1.1–82

Monitoring Technology Comparison

- **Ground- or structure-mounted or ground vehicle sensors**
  - Generally, most expensive ($40,000-$200,000) though some models of other types of monitors can be as expensive
  - Measurement range (typically up to ~40 ppm) reaches much lower than that for low-cost, portable, and hand-held sensors



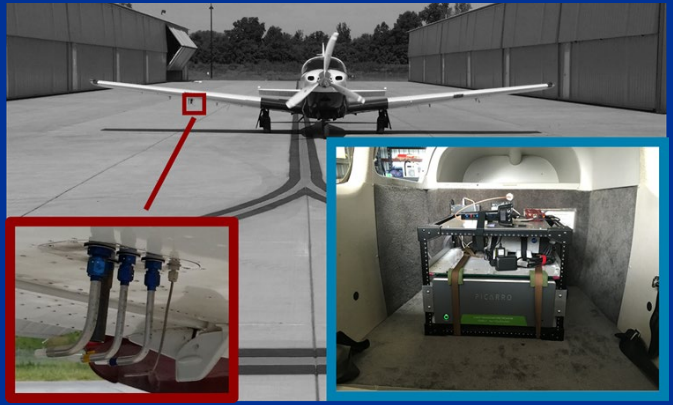
- **Low-cost, portable, and hand-held sensors**
  - Cost ranges from $10-$2,000; as high as $30,000-$100,000
  - Typical range: 0 ppm to 1,000-50,000 ppm
  - Accuracy, precision, and sensitivity did not vary greatly from specifications for ground-based or stationary structures

Image source: https://www.flir.com/discover/instruments/gas-detection/ogi-culture-of-safety/; Courtesy FLIR Systems

Monitoring Technology Comparison

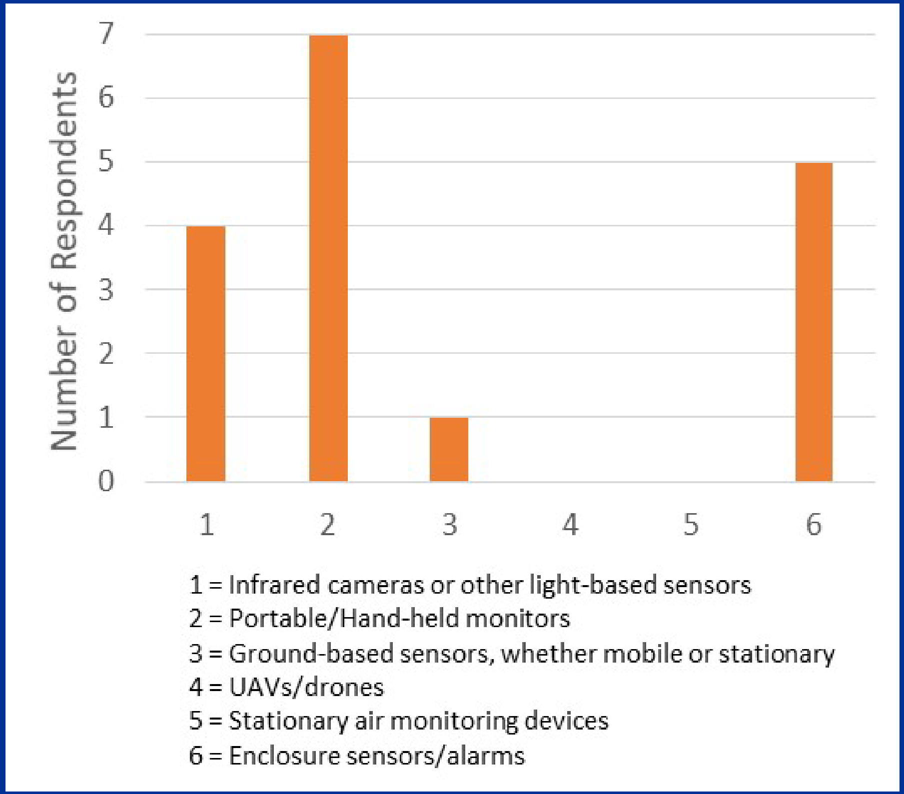
- **Drone-mounted monitors**
  - Generally, less accurate, precise and sensitive
  - Upper limit of measurement range is similar to low-cost, portable, and hand-held sensors
  - Costs not available

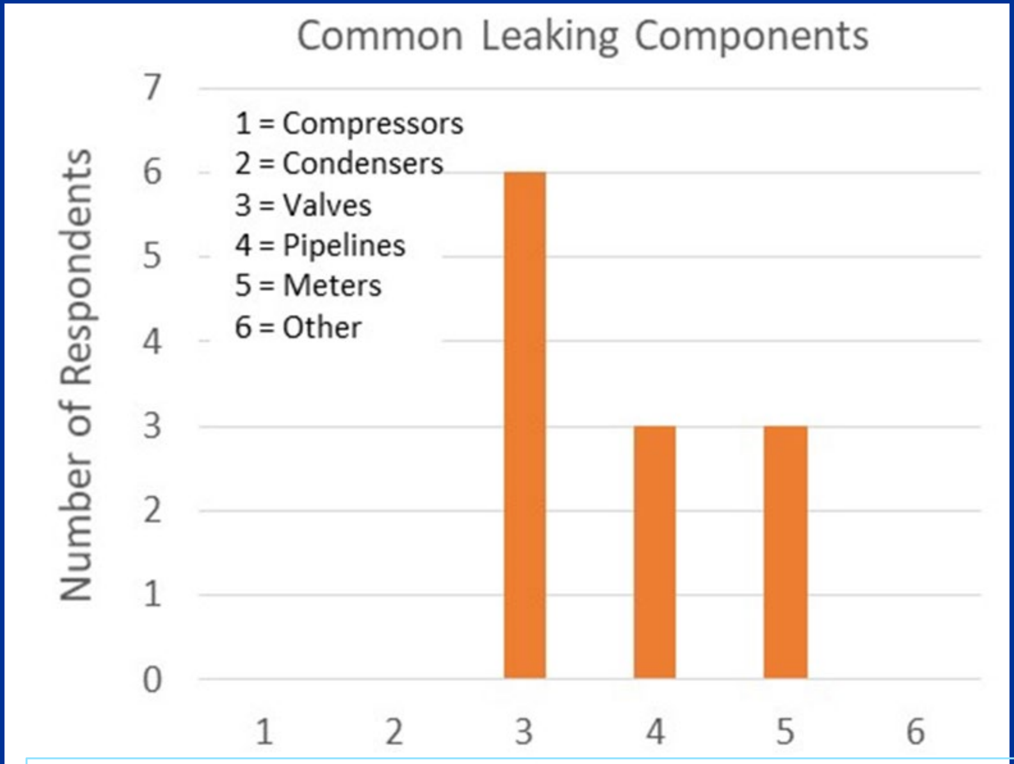
- **Aircraft-mounted monitors**
  - Measurement range similar to ground-based vehicle and stationary sensors
  - Cost ranges (select models) from $45,000-$100,000; similar to ground-based vehicle and stationary sensors



- **Satellite sensors**
  - Wide range in specifications and cost ($3,000-$100,000)

Survey of Utility Leak Monitoring





All respondents reported that stack emissions of CH_4 are estimated for reporting (e.g. GHGRP)

How is it determined to repair or replace a leak?

- "All are evaluated and assigned a repair schedule according to the location and magnitude. Immediately hazardous leaks repaired same-day. Non-hazardous are assigned a 1-year repair schedule or re-evaluation schedule, or both."
- "Unit start-up requirement."
- "When alarm is generated."

Multi-tiered GHG Emissions Measurements of California's Natural Gas Infrastructure

Large Facility Measurements

- 3 power plants or industrial sites
- Integrated monitoring approach (handheld, ground and aircraft mounted sensors, stack measurements)

Small Facility Measurements

- 27 CNG fueling stations with intensive surveys
- 19 CNG stations quick-scanned

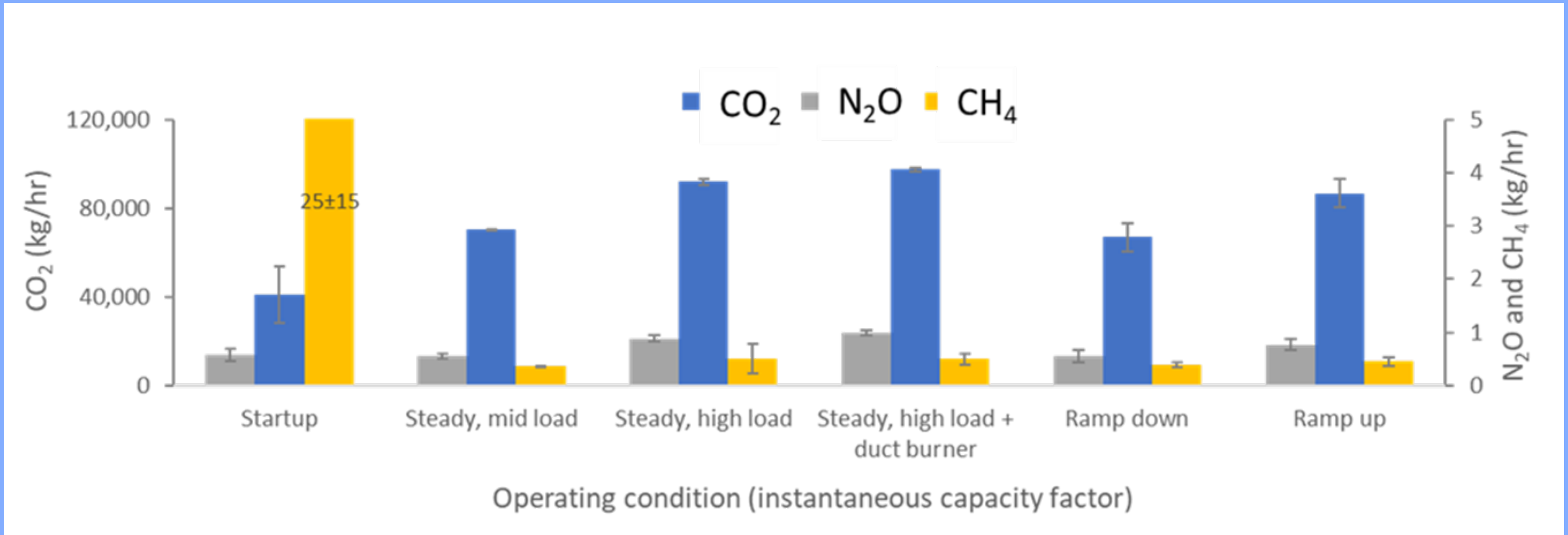
Provides needed end-use emissions measurements for sample of industrial facilities and documents feasibility

Combined Cycle Natural Gas with Post-Combustion NOx Control

SITE 1

- Stack CH_4 consistently very low and close to detection limit at 0.3 ± 0.15 kg/hr
- Total fugitive leak CH_4 rate of 0.39 kg/hr (~0.0007% of average hourly natural gas fuel use from that month in a prior year)
- 4 of 6 flights aligned with ground-level & stack data. 2 of 6 flights had interference from nearby biogenic (confirmed by stable carbon isotopic analysis)

SITE 2



Mix of operational states: hot-start, ramp up and down, steady state

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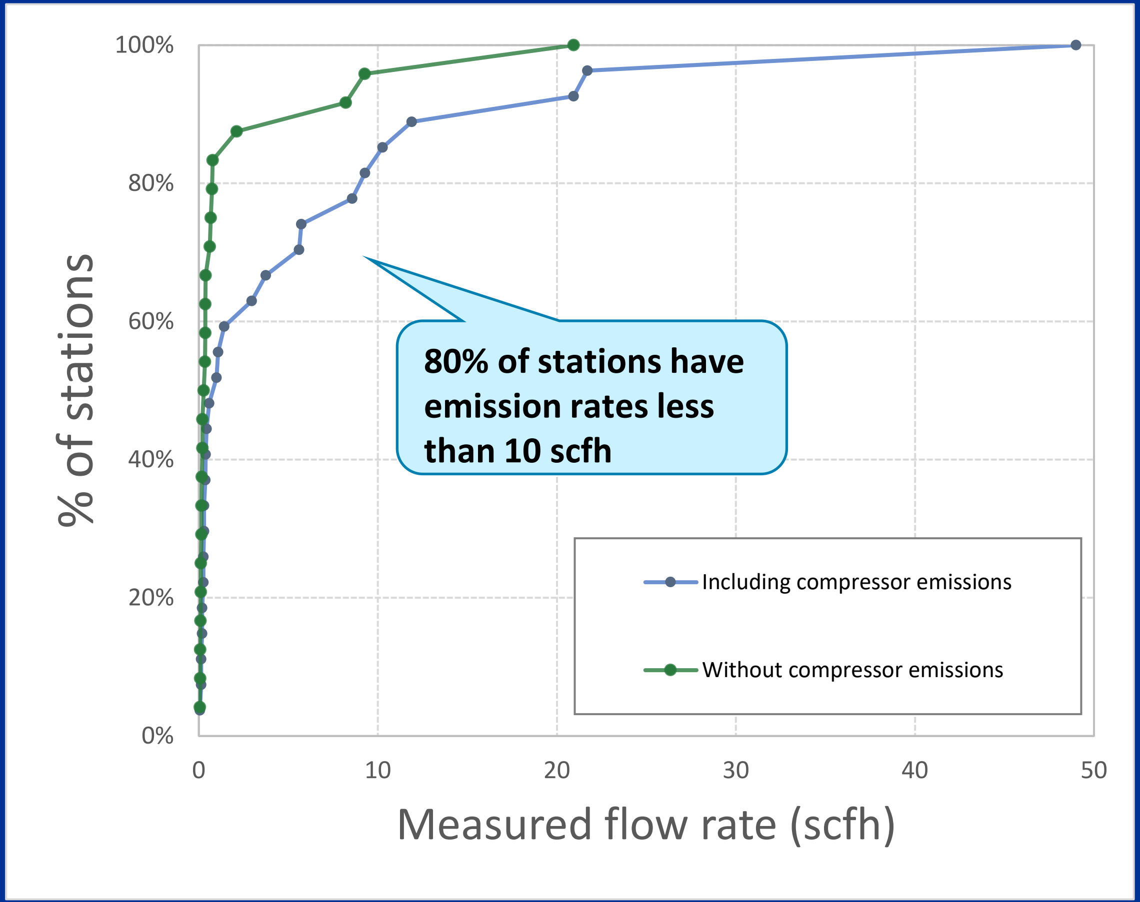
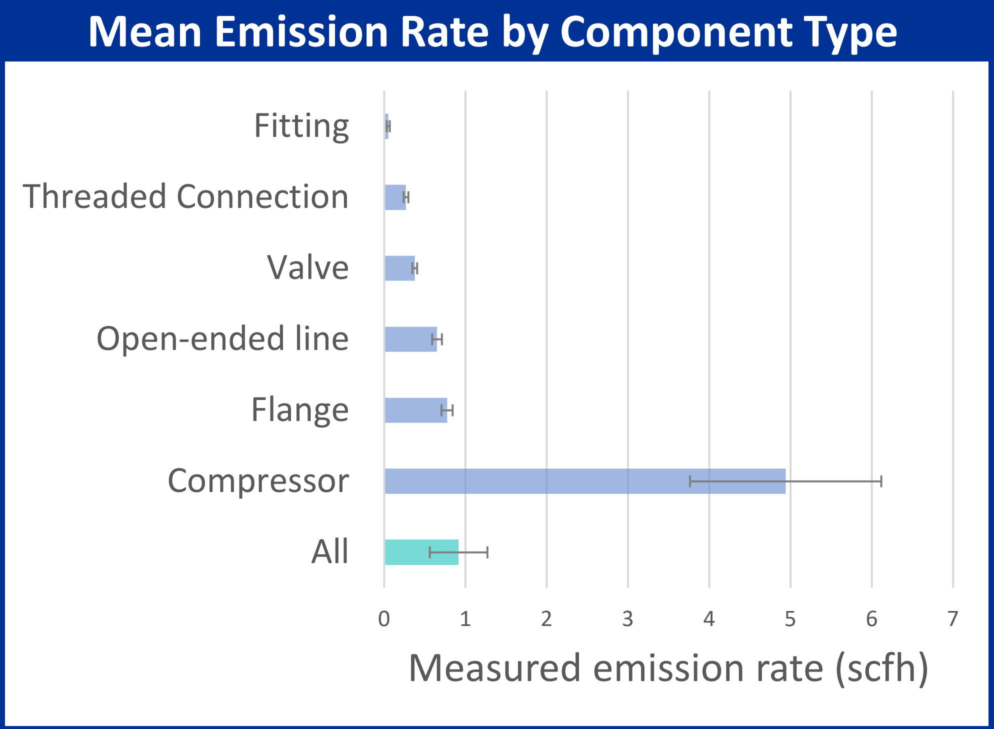
Emissions for CNG Fueling Stations





- *Only leak indications or emission points above detection limit included*
- *Emission indications at compressors were a potential mix of vents and leaks; thus categorized separately as "compressor emissions"*

Average of 5.5 non-compressor leaks and 0.8 compressor emission indications per station visit

CEC Grant: Characterizing Emissions from Biomethane Facilities

- AB 32 Scoping Plan suggests GHG mitigation strategies for sectors including energy, agriculture, waste management. Short-Lived Climate Pollutant Strategy requires 40% CH_4 emission reduction from 2013 levels by 2030.
- Real-time direct and fugitive GHG and air pollutant emissions during operation, **before and after capture**
- Apply flux chambers, mobile lab, UAV curtain techniques

Aerobic: Napa Composting

Anaerobic: Yolo County Landfill

City of Davis

Charles Ahlem Ranch Dairy

Formulate feasible emission mitigation recommendations

Charles Ahlem Ranch Dairy

Current system (before digester)	After digester
Lagoon	Effluent storage
Settling basin	Manure solids
Manure solids	Transfer pumps
Transfer pumps	Irrigation pumps
Irrigation pumps	Mechanical separator
Mechanical separator	Lift pump
Lift pump	Flush pump
Flush pump	Sump pump
Tractor	Digester mixer
Front loader	Tractor
	Front loader
	H_2S removal equipment
	Biogas compression
	Biomethane upgrade (at Himar Hub)

Mobile lab (e.g. spectroscopy, compliance grade)

Floating flux chambers

Relevant Federal Actions

Upstream CH_4 reductions & reporting changes will help downstream users

- **Regulation:** EPA Final O&G Rule (May '24)
  - Allows advanced monitoring techniques; will improve accuracy and source category breadth
  - Superemitter program from high altitude/satellite data
  - Add/revise calculations to improve accuracy, include empirical data
  - Reporting requirements to collect verification data, ensure accurate reporting, and improve the transparency
- **Investment**
  - DOE $850M to reduce emissions from small operators, repair low-producing wells, make empirical data transparent, enhance source quantification

Other Research Needs

Scope 3 Emissions Remain a Challenge to Identify and Quantify

- E.g., upstream fuel extraction, processing and transport for fuels consumed by electric generation
- Allocation of suppliers' emission sources to customer use, and boundaries, not always documented
- Supplier-specific harder to acquire than general averages
- PPA fuel or electricity can be unspecified, with high uncertainty

Access EPRI Tutorial

Many Unknowns Remain in Methane Emission Identification, Quantification and Mitigation

Methane Emissions R&D can Serve as a Guide for Future Hydrogen Emissions

CLIMATE IMPACTS

- H_2 emissions can indirectly affect global warming
  - More O_3, Strat. H_2O
  - Longer CH_4 life
- GWP_{100} of 11.6 ± 2.8
- Differing perspectives on the net impacts of H_2 emissions
  - H_2 emission rates
  - Upstream CH_4 leakage

EMISSIONS DATA

- Very little data exists on H_2 leakage and/or venting rates
  - Estimates, simulations & assumptions put it at 0.2-30%
  - No empirical data
- Lack of clarity of emissions along future H_2 value chain

TECHNOLOGIES

- H_2 detection technologies are in their infancy
- Existing tech is focused on safety
- H_2 is hard to detect through conventional spectroscopy
- Low-level detection and quantification critical to developing emissions estimates

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