Methane emissions from upstream oil and gas systems: non-producing wells and unlit flares

Mary Kang, Civil Engineering (she/her, elle)

September 10, 2024

SHEAL
Subsurface Hydrology and Environmental Analysis Laboratory

McGill

Overview of PTAC-funded Projects

Previous PTAC-funded project

- Evaluation of surface casing vent flows at inactive wells (2021 and 2022 Field Campaigns)

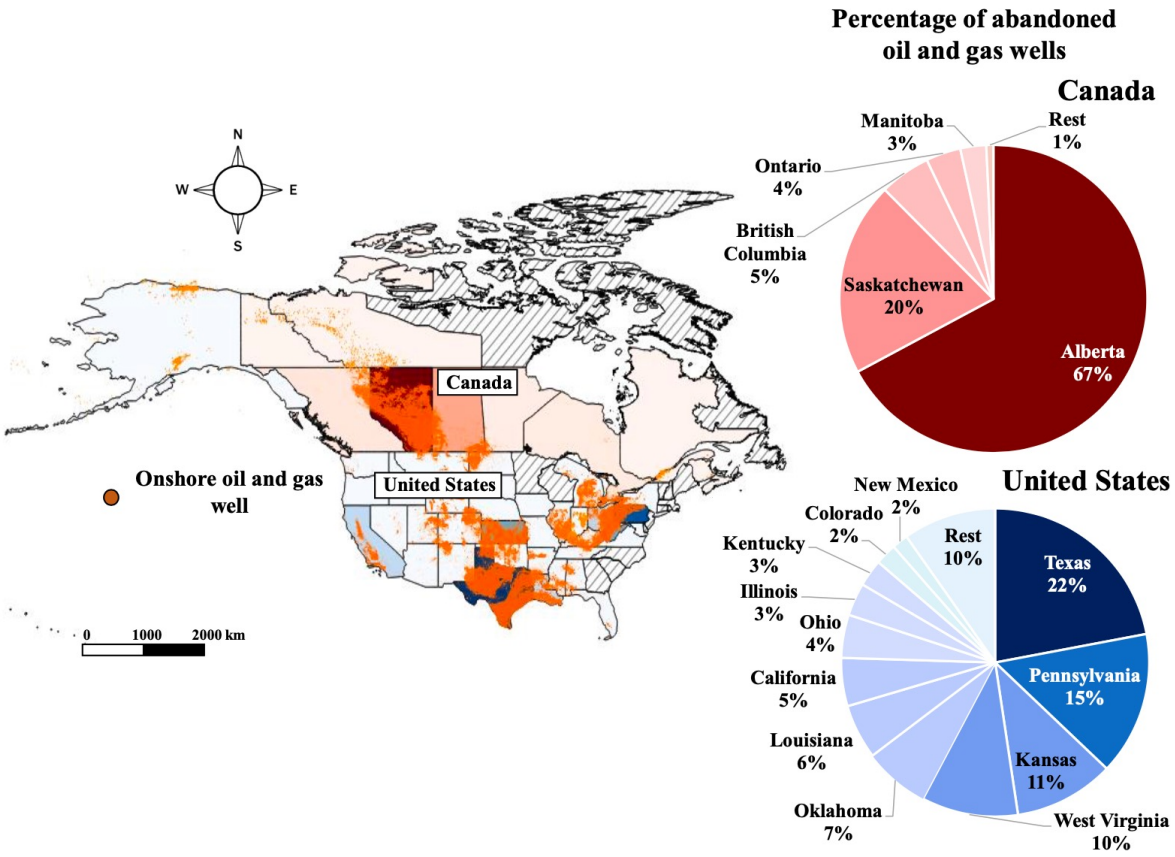
On-going PTAC-funded projects

- Temporal variability in methane and air pollutant emissions from abandoned, inactive, and suspended oil and gas wells (2024 Field Campaign)
- Unlit Flares: Aerial Quantification of a non-Inventoried Emission Source in Western Canada (2023 Field Campaign)
- Unlit Flares: Detection Sensitivity and Repeat and Expanded Measurements of a non-Inventoried Emission Source in Western Canada (2024 Field Campaign)

Methane emissions from non-producing oil and gas wells

~400,000 non-producing oil and gas wells in Canada

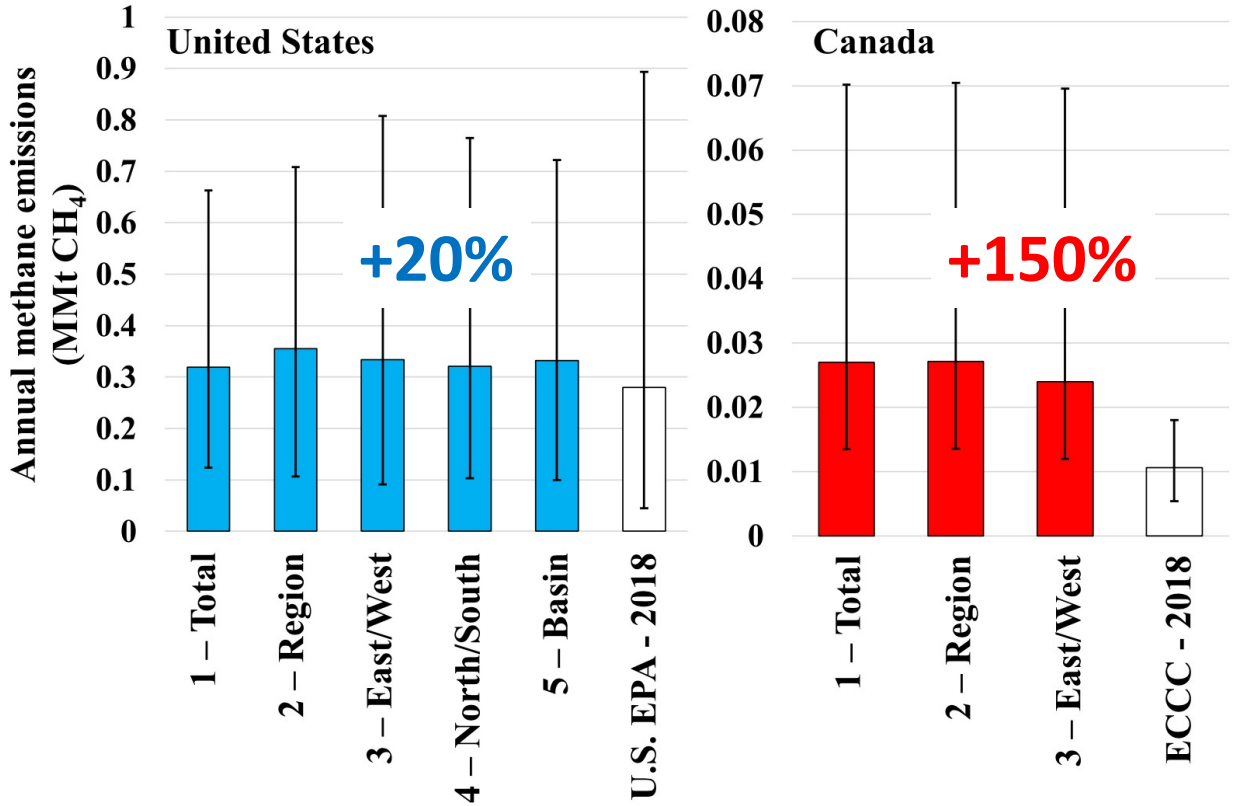
~4 million non-producing oil and gas wells in the U.S.



Williams, Regehr, and Kang (2021)

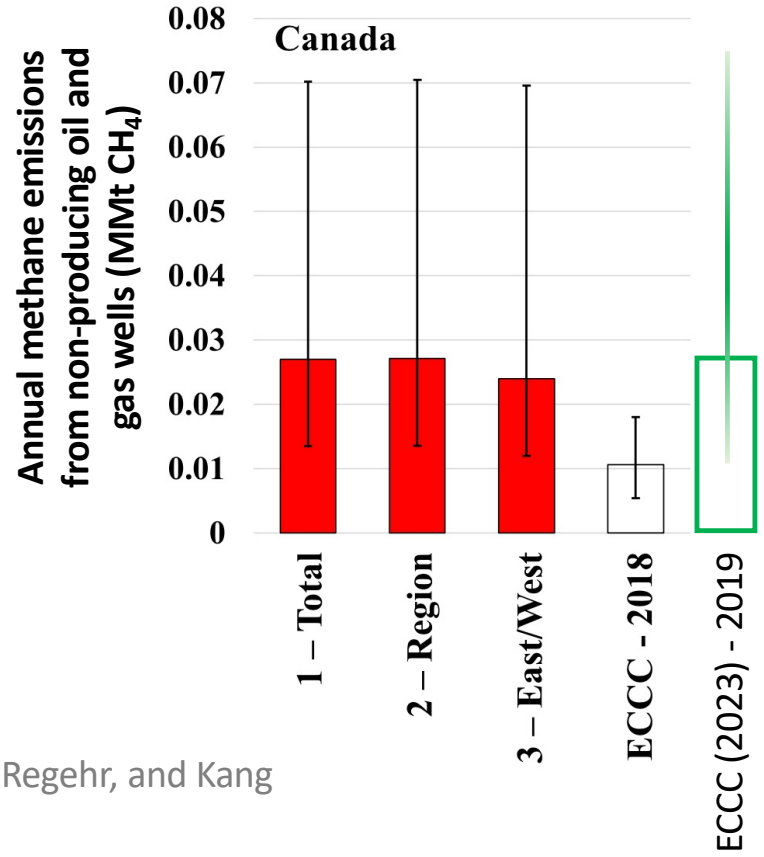
Methane emissions from non-producing oil and gas wells are underestimated

Based on 598 direct measurements in Canada and the US, which is very small relative to the number of non-producing wells



Williams, Regehr, and Kang (2021)

Increase by 2.5x with country-specific measurements in Canada

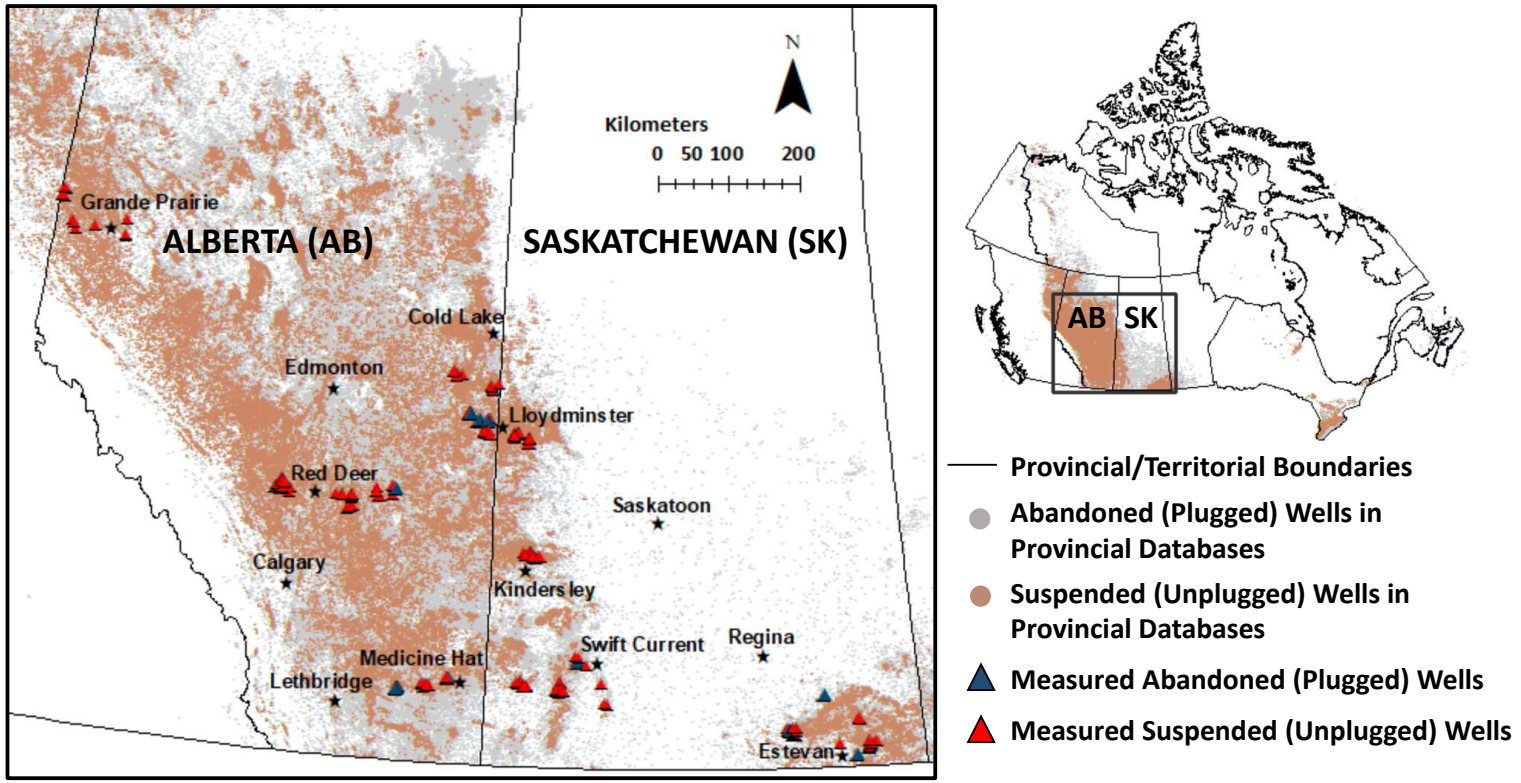


What is the uncertainty range??

2.5x increase

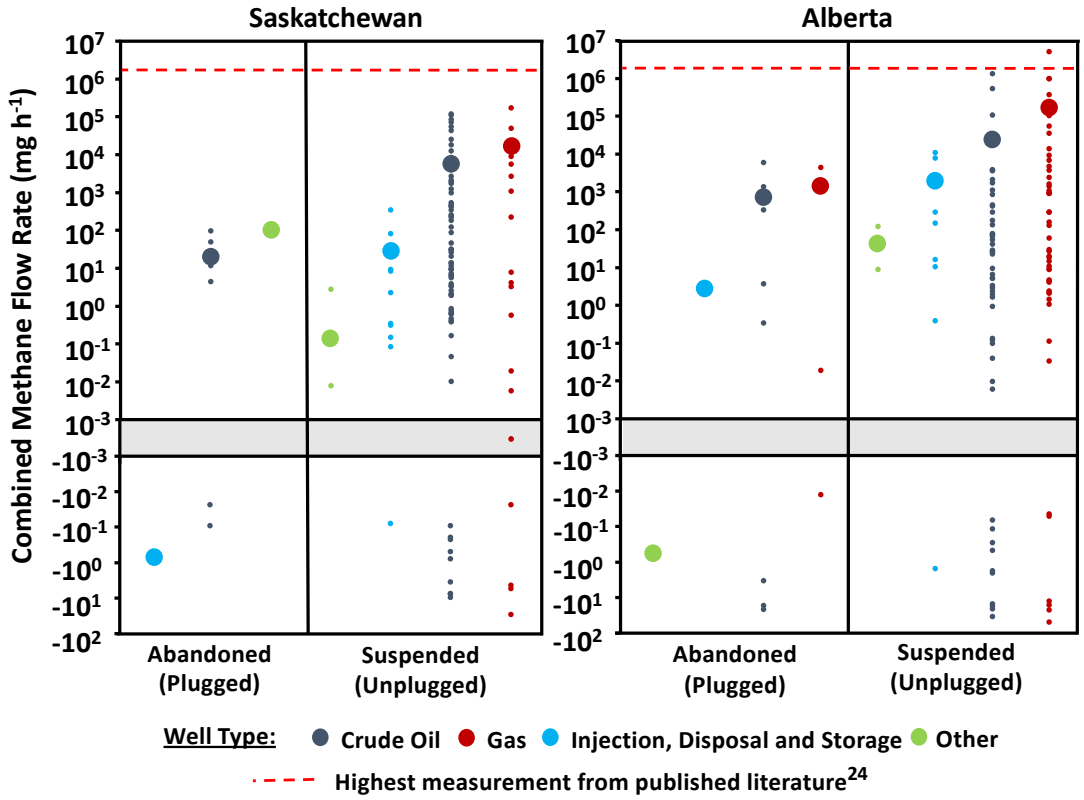
Adapted from Williams, Regehr, and Kang (2021)

238 direct measurements of abandoned and suspended oil and gas wells in AB and SK



Bowman et al. (2023)

Highest emitting non-producing well emission rate exceed previously published top rate by 2-3x

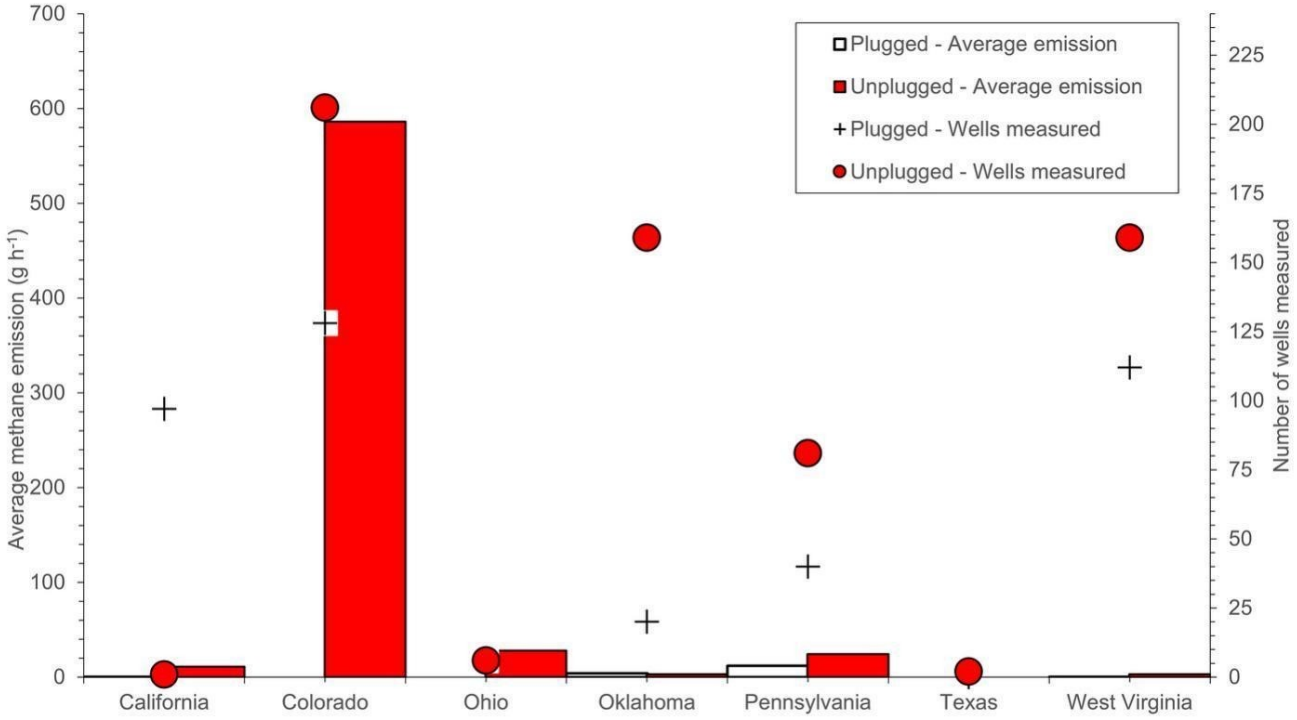


Our highest measured emission rate (5.2 × 10^6 mg CH_4/hr or **5.2 kg CH_4/hr**) from an unplugged gas well in Alberta was 2-3x higher than the largest previously published emission rate from an abandoned well (Pennsylvania, USA) (Etiope et al., 2013).

But new highest measured emission rate at an abandoned well in Colorado is **76 kg CH_4/hr** (Riddick et al., 2024).

Bowman et al. (2023)

Colorado State's Energy Institute* study suggests non-producing wells emit 22–49% of total active oil and gas production in the US



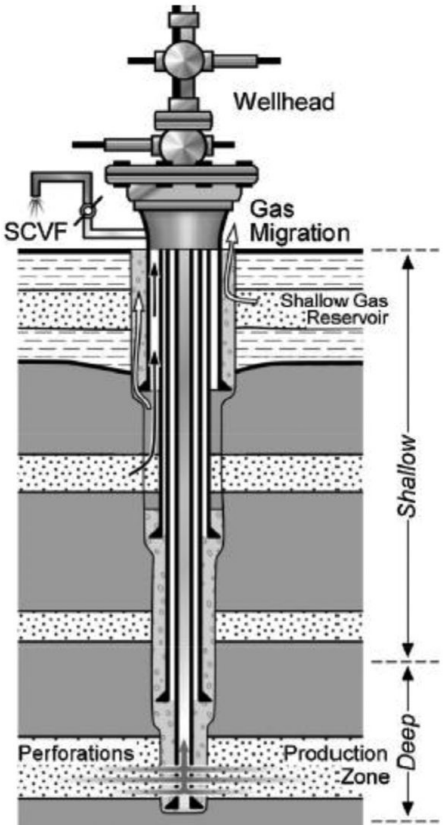
* Methane Emissions Technology Evaluation Center (METEC) is housed within the Energy Institute of Colorado State University

Riddick et al. (2024)

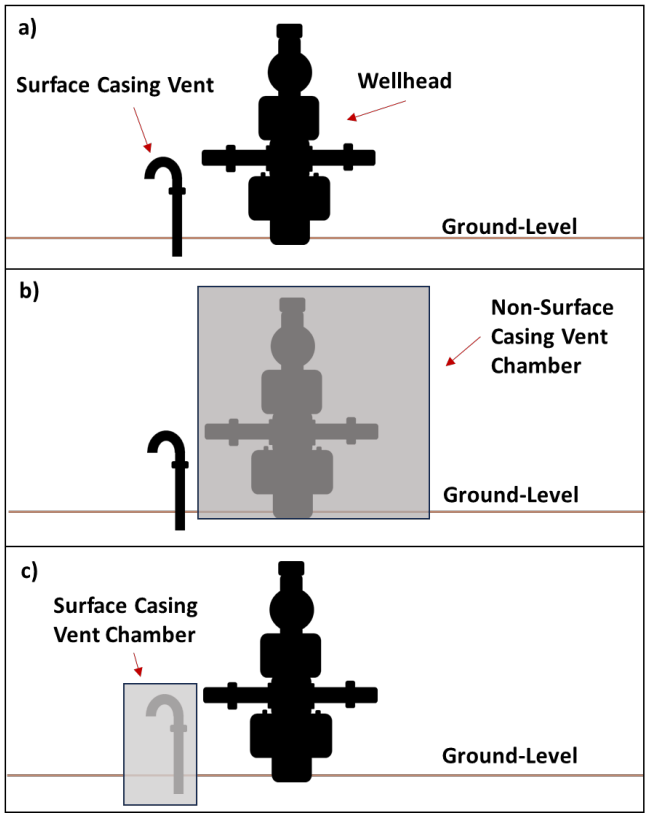
Separately measuring methane emissions from SCV and wellheads at non-producing wells

Surface Casing Vent Flow (SCVF): Refers to the surface release of fluids and/or gas in any combination or volume between the production casing and surface casing.

Gas Migration: Refers to situations where gas from stratigraphic units penetrated by the well is present at surface in soils around the outermost string of well casing.

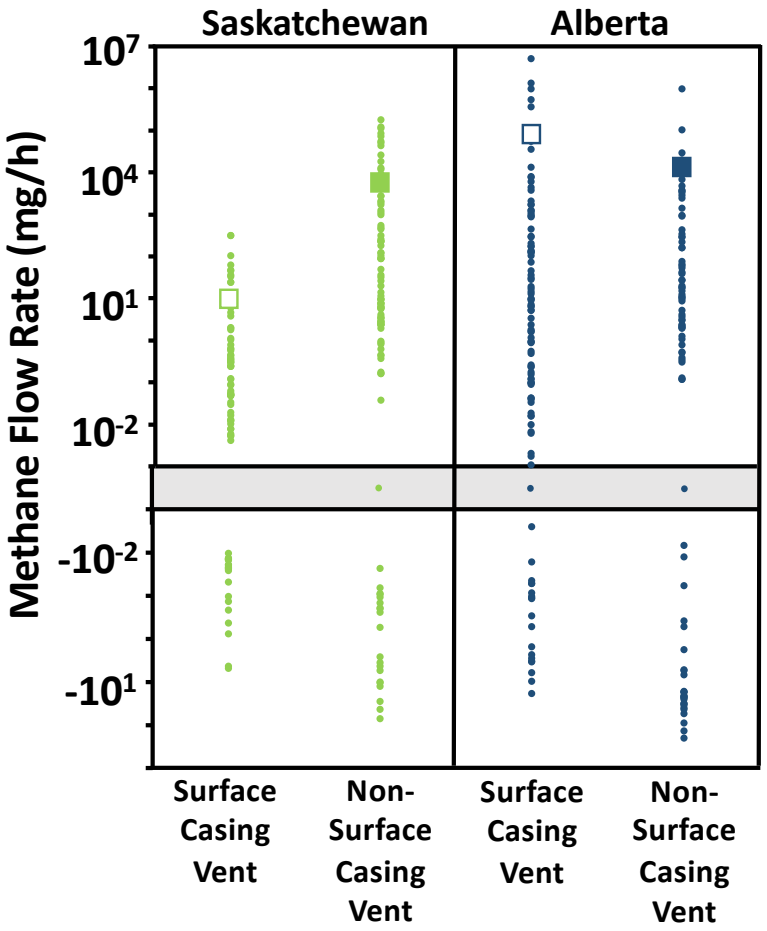


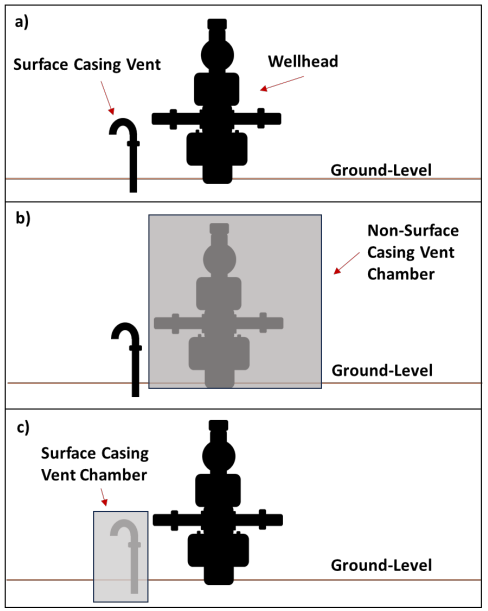
Watson and Bachu (2008)



Bowman et al. (2023)

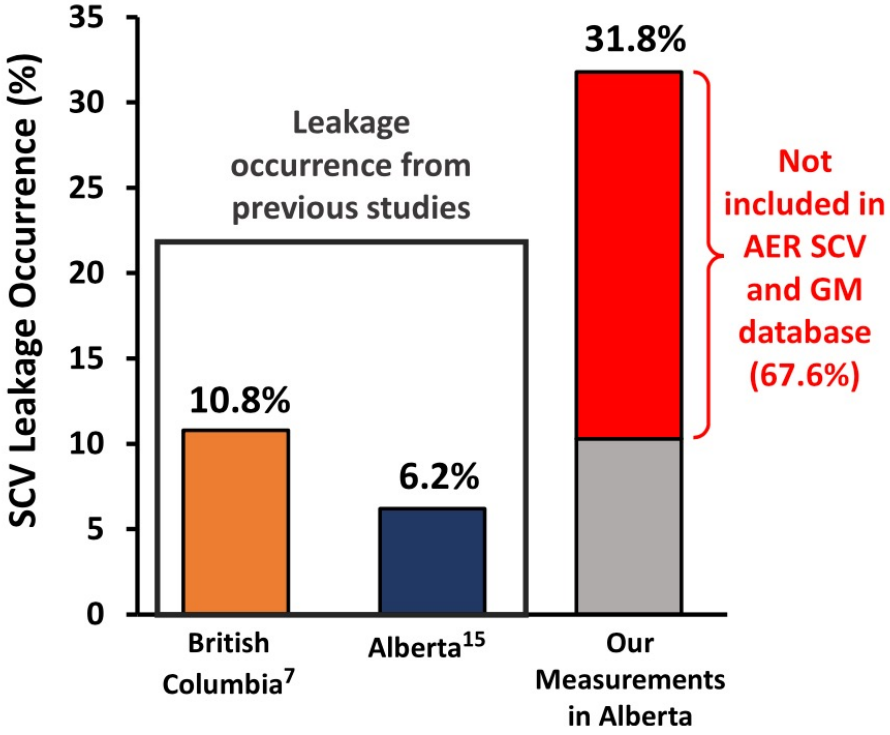
Surface casing vent flows dominate methane emissions from non-producing wells in Alberta, but not in Saskatchewan



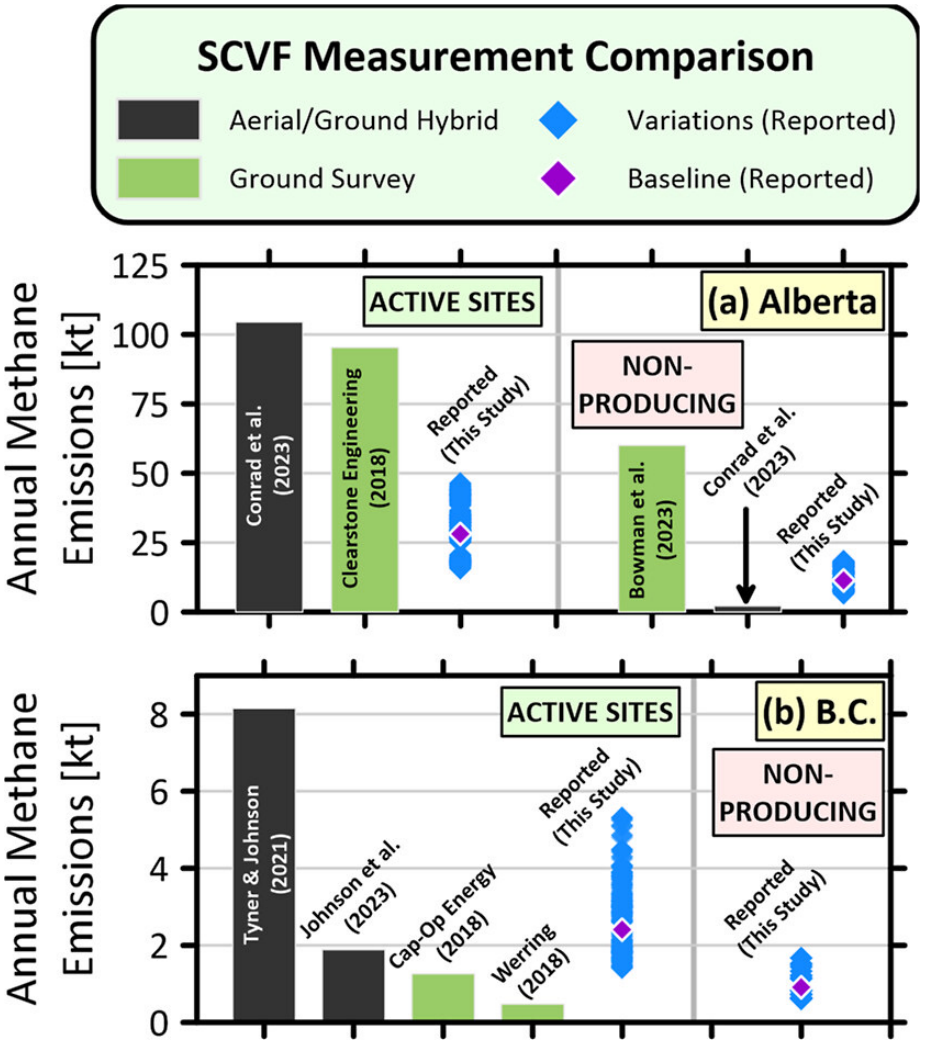


Bowman et al. (2023)

SCV leakage occurrence and annual methane emissions highly uncertain

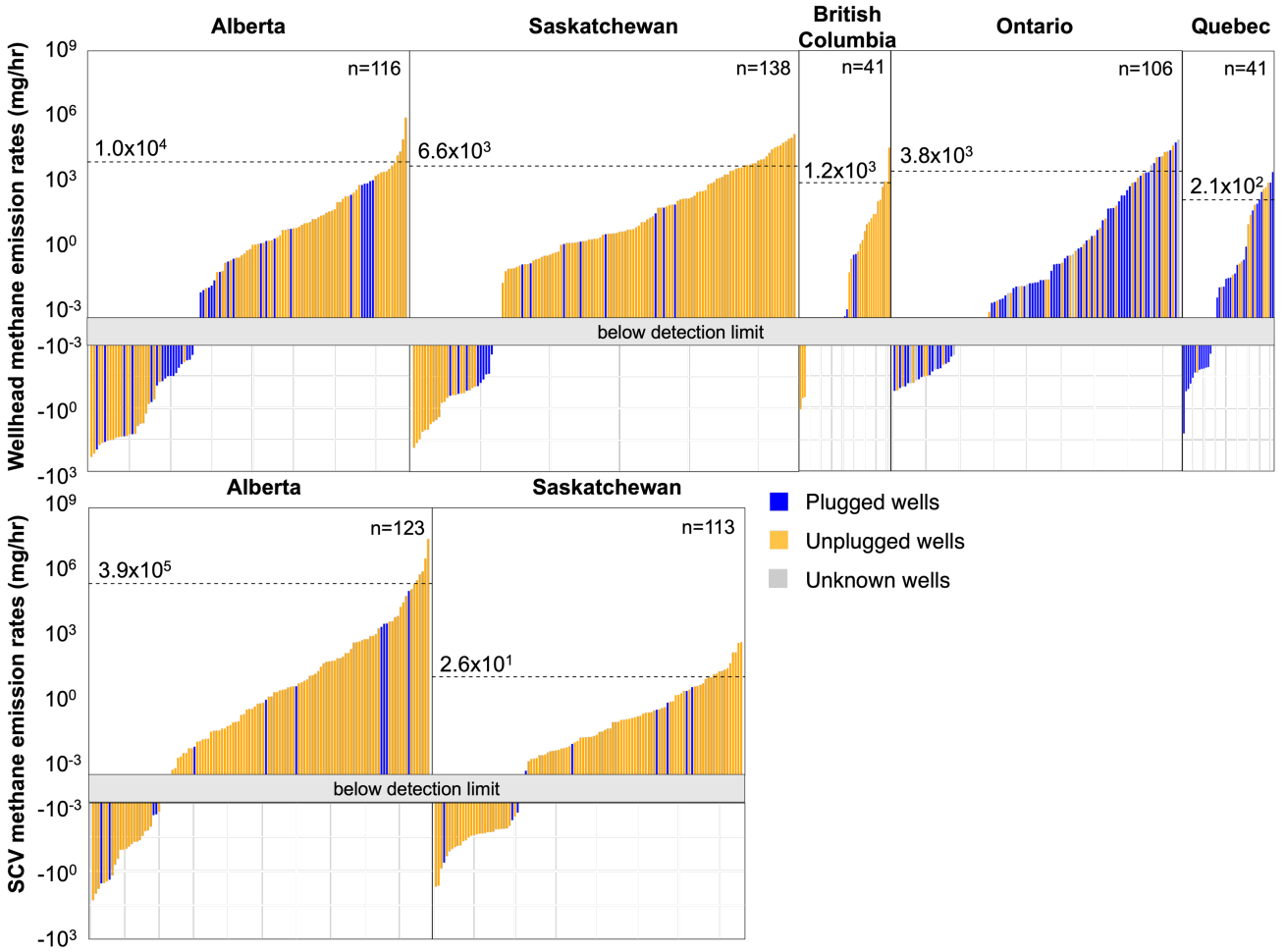


Bowman et al. (2023)



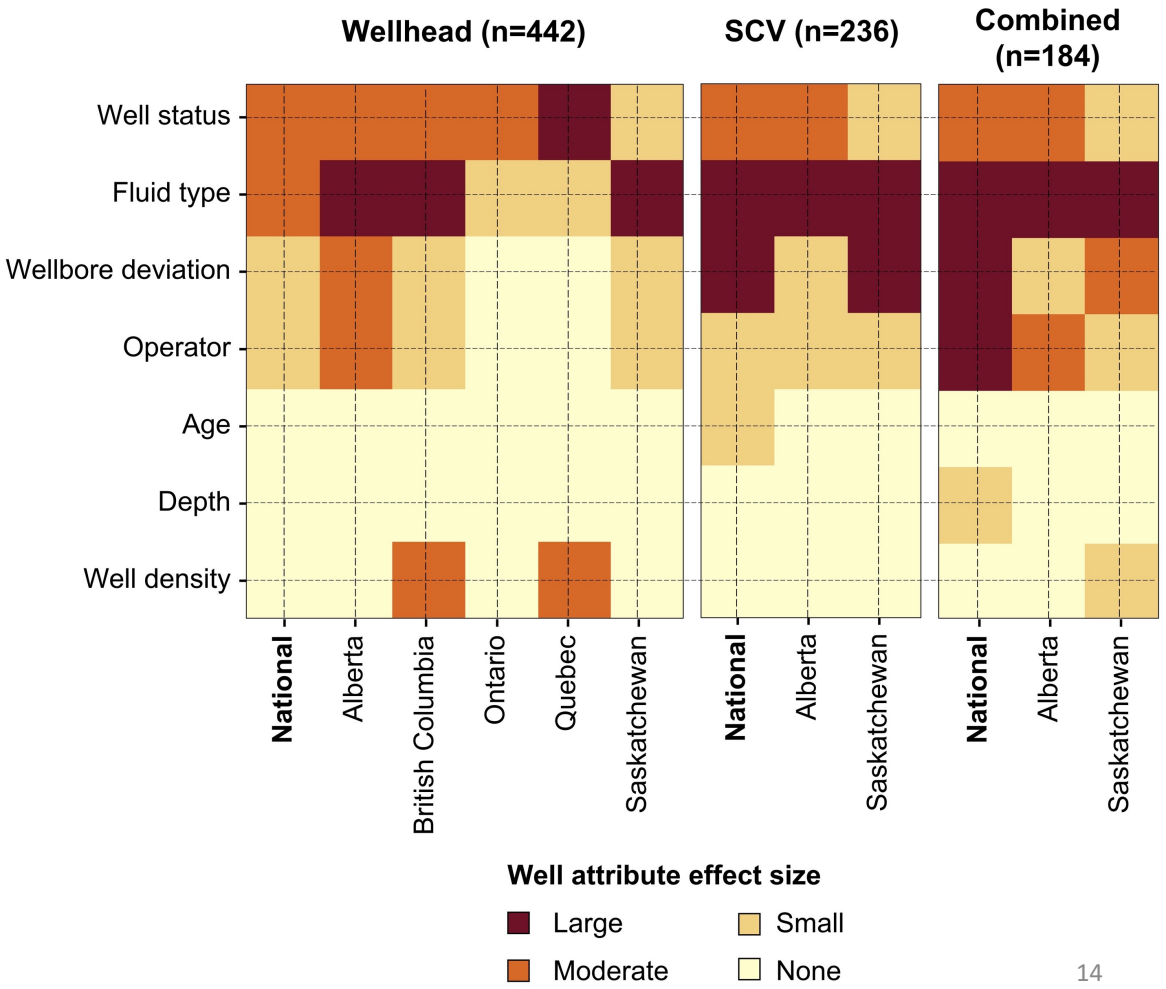
Seymour et al. (2024)

494 direct measurements of non-producing oil and gas wells across Canada



Klotz et al. (In Review)

Relationship with well attributes vary with geographical location



Klotz et al. (In Review)

Overview of 2024 Field Campaign (PTAC & NSERC-funded)

Well Status/Province	AB	BC	ND	SK	Total
Abandoned	17	2	3	0	23
Downhole Abandoned	3	5	0	5	13
Suspended	6	1	5	16	28
Other	1	1	0	0	1
Total	27	9	8	21	**65**

Type of Measurement	AB	BC	ND	SK	Total
Short-Term* Temporal Variability	2	2	1	2	7
Long-Term** Temporal Variability	2	0	0	7	9
Short* and Long-Term** Temporal Variability	1	0	0	1	2
Total	5	2	1	10	**18**

*Hourly/Daily, **Multi-Year

Next Steps / On-Going Work

- Laboratory and data analysis for the 2024 Western Canada Campaign.
- Prepare and implement the 2025 Western Canada Campaign, funded by NSERC.
- Advanced geochemical analysis that provides insight into sources.

Unlit Flares: Aerial Quantification of a non-Inventoried Emission Source in Western Canada

Scott Seymour, Mary Kang

Background & Objectives

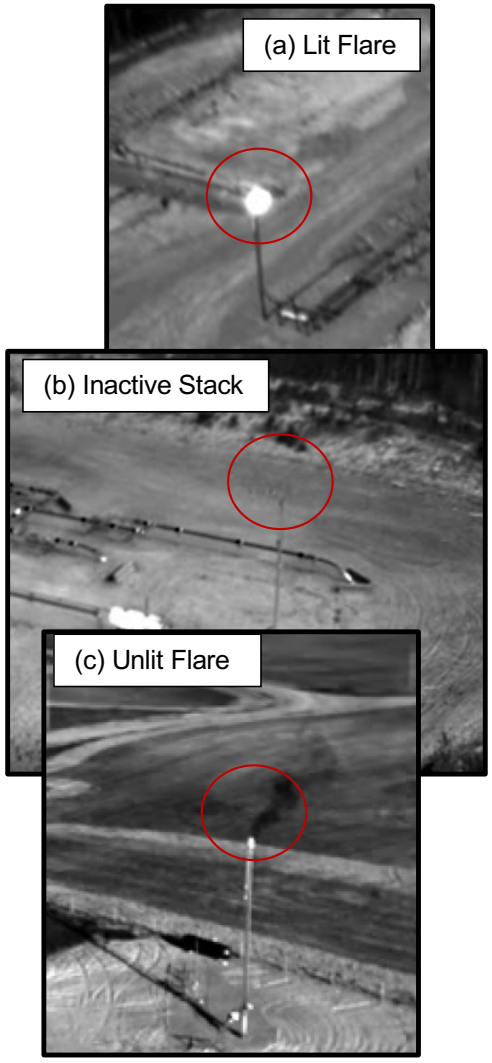
Unlit flares were not included in Canada's methane inventory

- Auditor General found this was a key missing component of federal inventory
- Flares assumed to operate at 98% efficiency

First unlit flare estimates estimated by ECCC using Bridger data

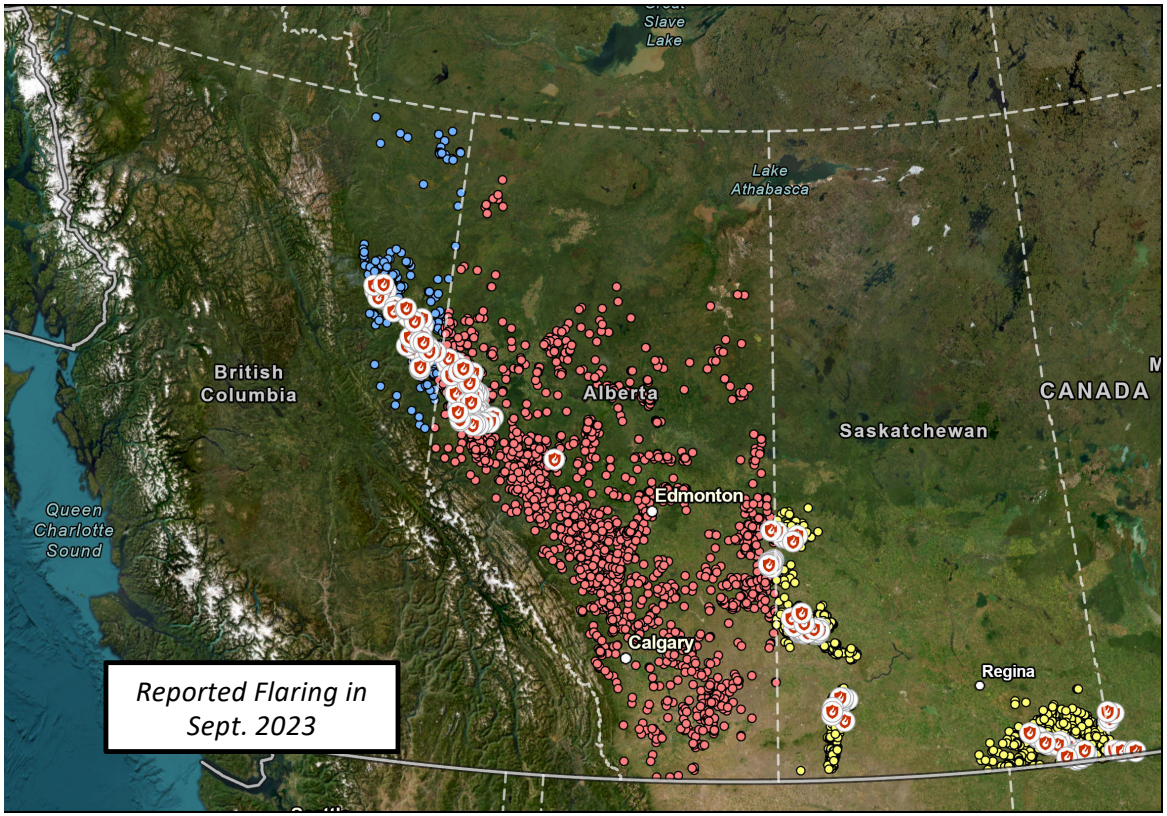
Research Objectives:

1. Quantify unlit flare fraction in Canada
2. Test relationships with site type, region, etc.
3. Compare with industry reporting (or satellite detections)



Survey Regions

- Surveyed sites representative of the site types reporting flaring to each province (322)
  - **BC**, mostly multi-well gas
  - **AB**, mix of oil and gas
  - **SK**, mostly crude/heavy oil



Survey Status

- **Primary survey completed as of Sept. 2023**
  - Optical gas imaging camera (FLIR GFX320) survey
  - Robinson R44 helicopter
- Surveyed 322 sites, observing 299 flare stacks and 55 combustors

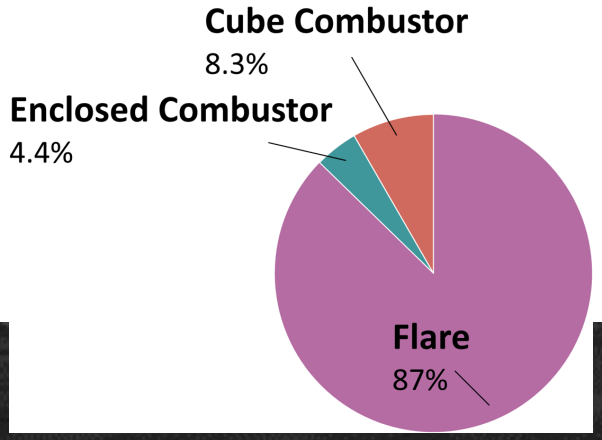
Survey Results

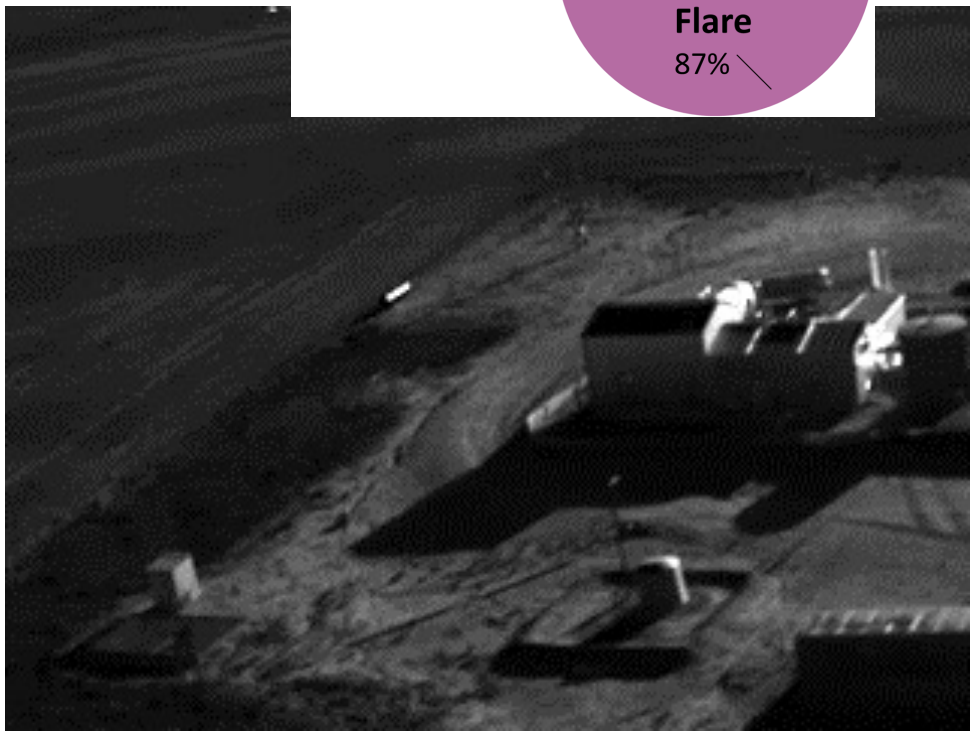
6% of flares were unlit

- 92.1% efficiency for flares (Bridger Photonics aerial surveys in Canada finding ~90.4% combustion efficiency)
- Flares were emitting 4x more methane, compared to assuming 98% efficiency

However, not all on-site combustion was through flaring

- Overall combustion operations (incl. flares and combustors) are 93% efficient (assuming combustors have 98% efficiency)





Next Steps / On-Going Work

1. **Controlled release testing**
   - Establish OGI camera detection limit
   - Determine whether any unlit flares might have gone undetected
2. **Expand helicopter survey (AUPRF 2024)**
   - Expand survey count and coverage
3. **Compare with satellite flare detections (VIIRS)**
   - Establish detection capability of satellite instrument
   - Compare with reported activity

Mary Kang, Ph.D., P.Eng.

Civil Engineering, McGill University

mary.kang@mcgill.ca

SHEAL
Subsurface Hydrology and Environmental Analysis Laboratory

McGill

Acknowledgements: Natural Sciences and Engineering Research Council of Canada (NSERC), Fonds de Recherche du Québec - Nature et Technologies (FRQNT), Canada Foundation for Innovation (CFI), Environment and Climate Change Canada (ECCC), Government of the Northwest Territories (GNWT), United Nations Environment Programme (UNEP), Petroleum Technology Alliance of Canada (PTAC), Clean Resources Innovation Network (CRIN), McGill Sustainability Systems Initiative (MSSI), Environmental Defense Fund (EDF), Mathematics of Information Technology and Complex Systems (Mitacs), Clean Economy Fund, and CANMET/Natural Resources Canada (NRCan).