

# Methane emissions from non-producing oil and gas wells: Direct measurements and data analysis

**Mary Kang**

Civil Engineering, McGill University

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# Overview

- What are non-producing oil and gas wells?
  - Definitions, well counts, environmental risks and opportunities
- How much methane do non-producing wells emit?
- What do we do about these wells?
  - Plugging and repurposing

# What is a non-producing oil and gas well?

*Definition of “abandoned oil and gas wells” varies among states/provinces/territories/countries*

The definition by the U.S. Environmental Protection Agency in the U.S. Greenhouse Gas Inventory (2019-2023):

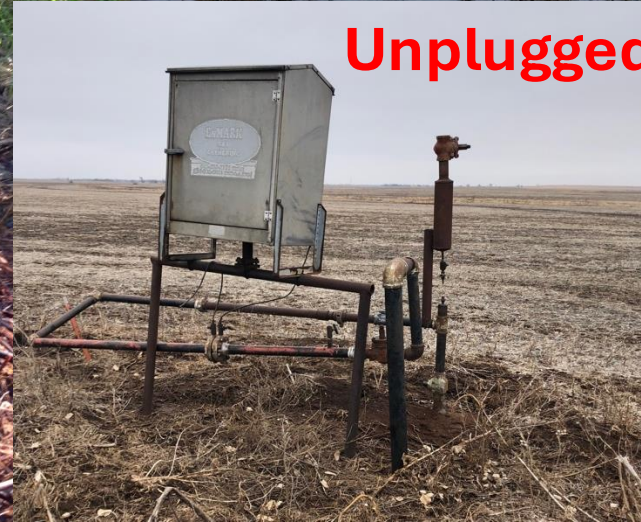
*The term “abandoned wells” encompasses various types of wells:*

- *Wells with no recent production and **not plugged**. Common terms (such as those used in state databases) might include: inactive, temporarily abandoned, shut-in, dormant, and idle.*
- *Wells with no recent production and no responsible operator. Common terms might include: **orphaned**, deserted, long-term idle, and abandoned.*
- *Wells that have been **plugged** to prevent migration of gas or fluids.*

In this presentation, “Abandoned” = “Non-Producing”



# Non-Producing Oil and Gas Wells





# Orphaned oil and gas wells: A definition

“Orphaned oil and gas wells are a category of unplugged nonproducing wells for which the operator is unknown, unavailable, or insolvent, leaving no responsible party to plug the well and restore the well site other than government agencies and the general public.” Boutot *et al.* (2022)

Well status	Production	Plugging status	Legal responsible operator	Financial responsibility	Examples of other terms used by states <sup>a</sup>
Abandoned Not incl. orphaned	Nonproducing or not authorized for production	Plugged or unplugged	Active and able to plug and remediate the well	Operator	Suspended, shut-in, temporarily abandoned, inactive, idle
Orphaned	Nonproducing or not authorized for production	Unplugged	Unknown, unavailable, or insolvent and is unable to plug or remediate the well	State, other government agency, and/or the general public	Abandoned, revoked, forfeited, unknown, shut-in

*All orphaned wells can be viewed as abandoned/non-producing wells.  
But not all abandoned/non-producing wells are orphaned wells.*

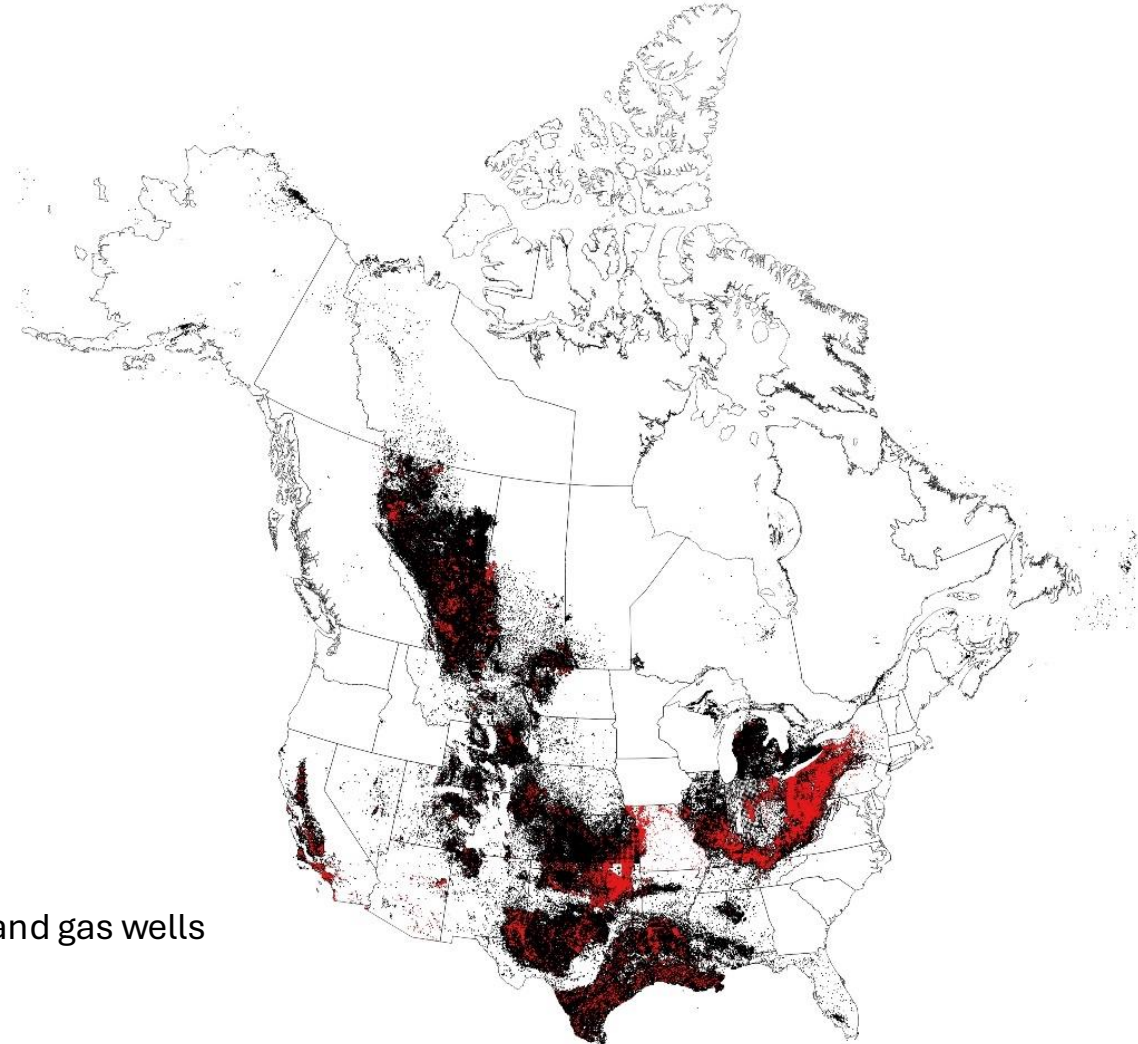
# 3.5 million **documented** non-producing oil and gas wells in Canada and the United States

Orphaned  
4%

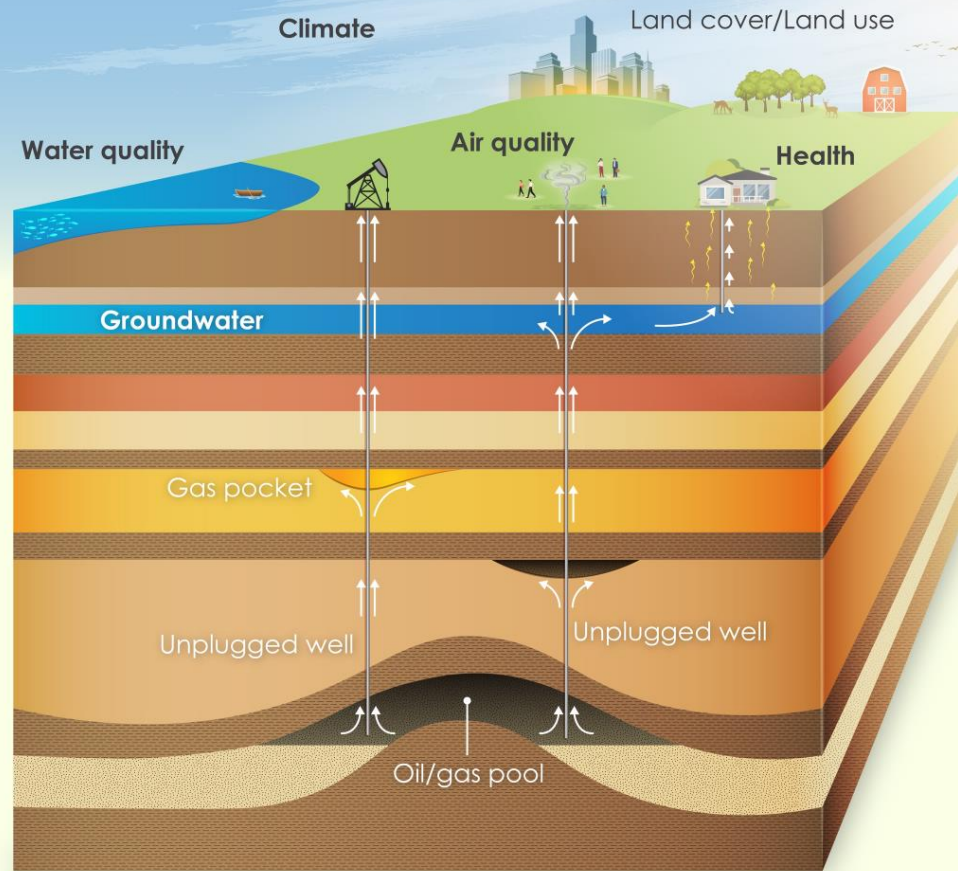


Total population breakdown

- Orphaned oil and gas wells
- Non-producing, minus orphaned, oil and gas wells

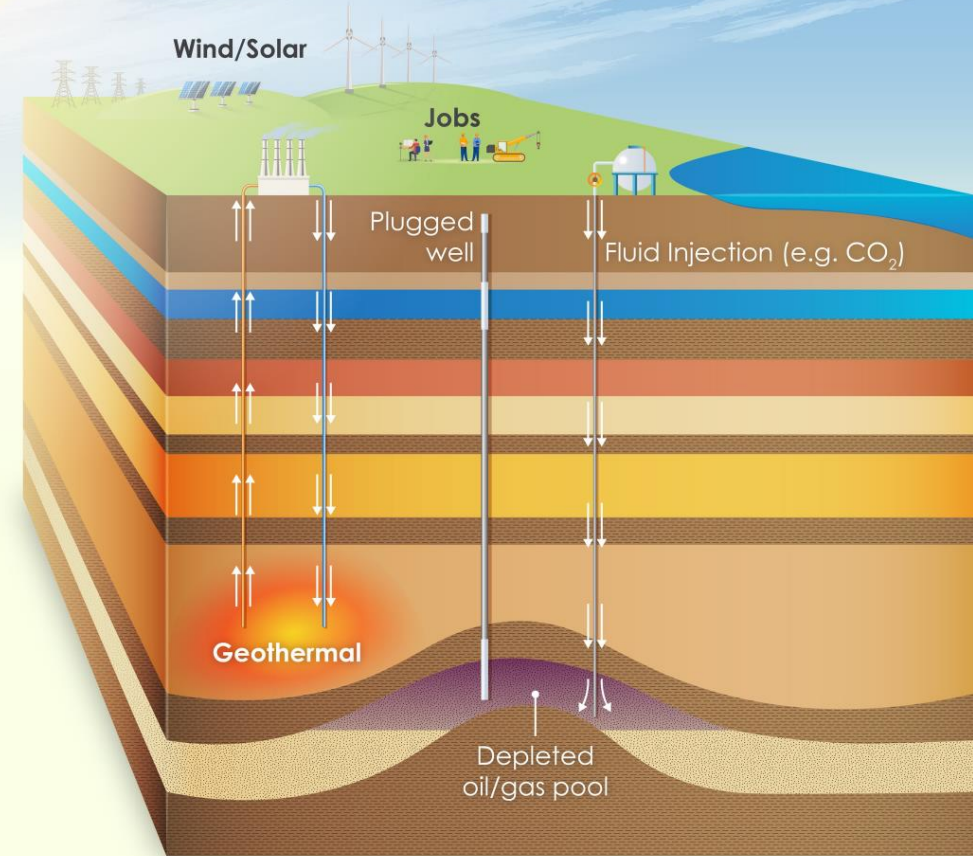


## Environmental Risks



<b>Climate</b>	Methane emissions (Fig. 3d)
<b>Groundwater</b>	Groundwater production well locations (Fig. 3b)
<b>Water quality</b>	Surface water and groundwater quality data availability (Fig. 3c)
<b>Air quality</b>	Methane emissions and benzene data (Fig. 3d and 3e)
<b>Health</b>	Potential exposures and health outcomes

## Opportunities



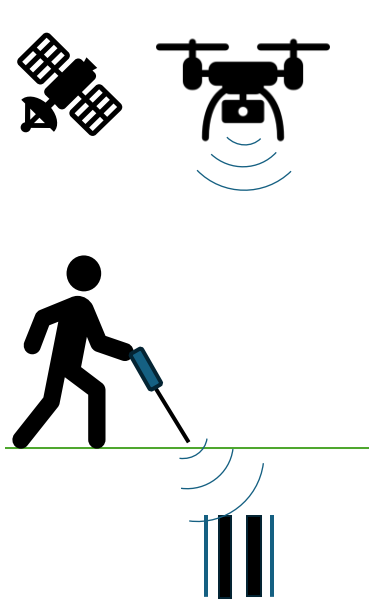
<b>Geothermal</b>	Enhanced geothermal system favorability (Fig. 4a)
<b>Geologic storage</b>	CO <sub>2</sub> , hydrogen, natural gas, etc. (Fig. 4b)
<b>Wind/Solar</b>	Wind/solar capacities (Fig. 4c and 4d)
<b>Jobs</b>	Directly related to plugging

How much methane do non-producing wells  
emit?

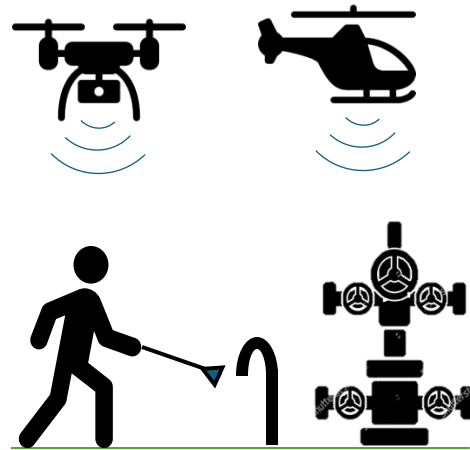


# Measuring methane emissions

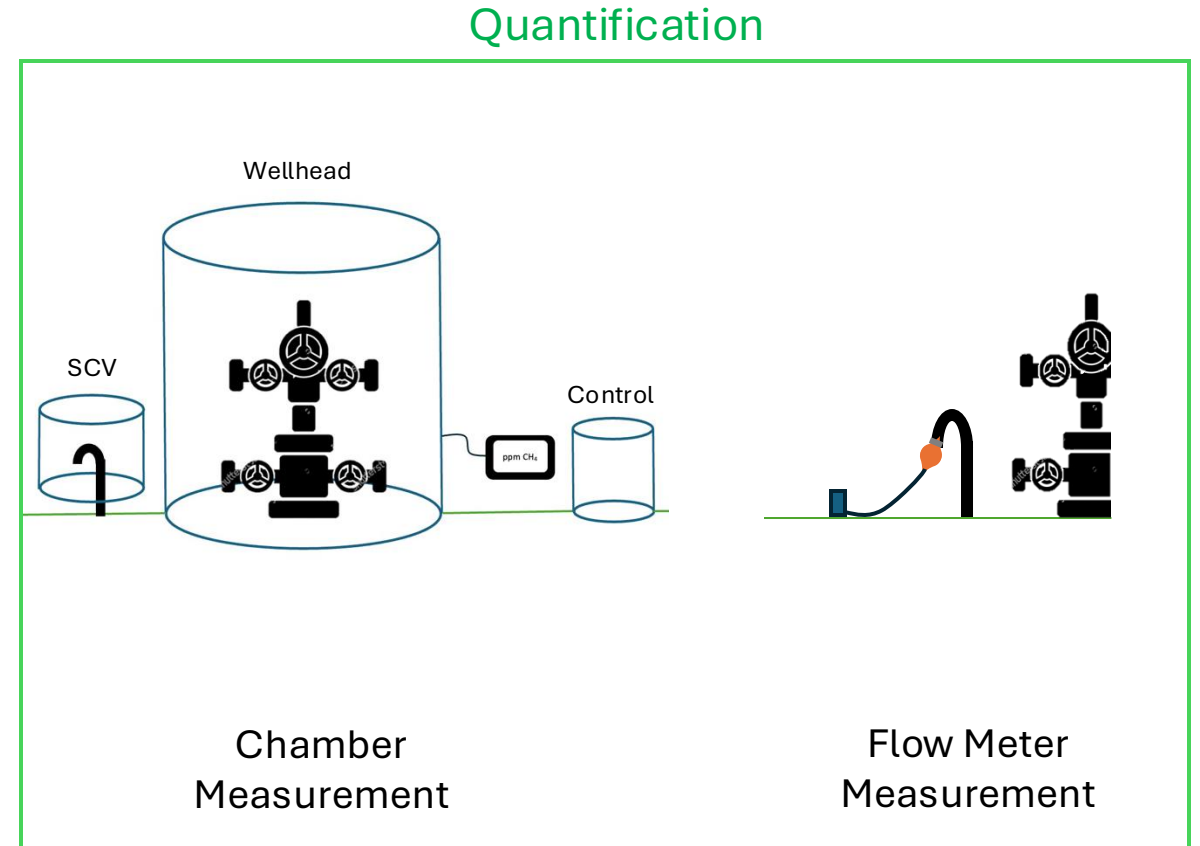
- Ground-based to aerial (drones, helicopters)



Well Location  
(Magnetometry)



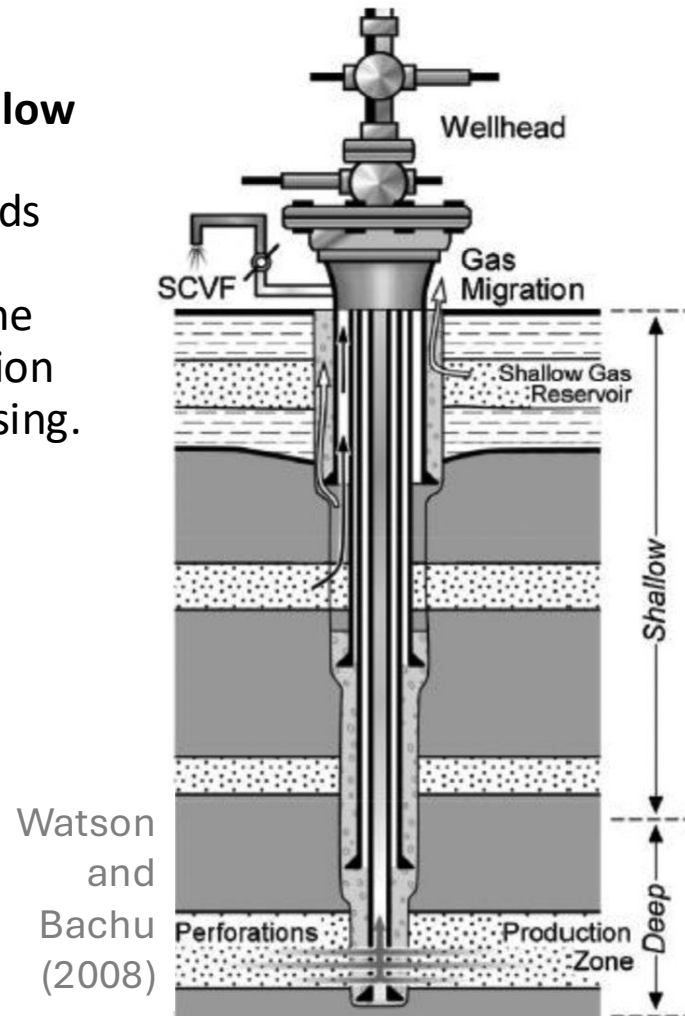
Methane Screening /  
Detection



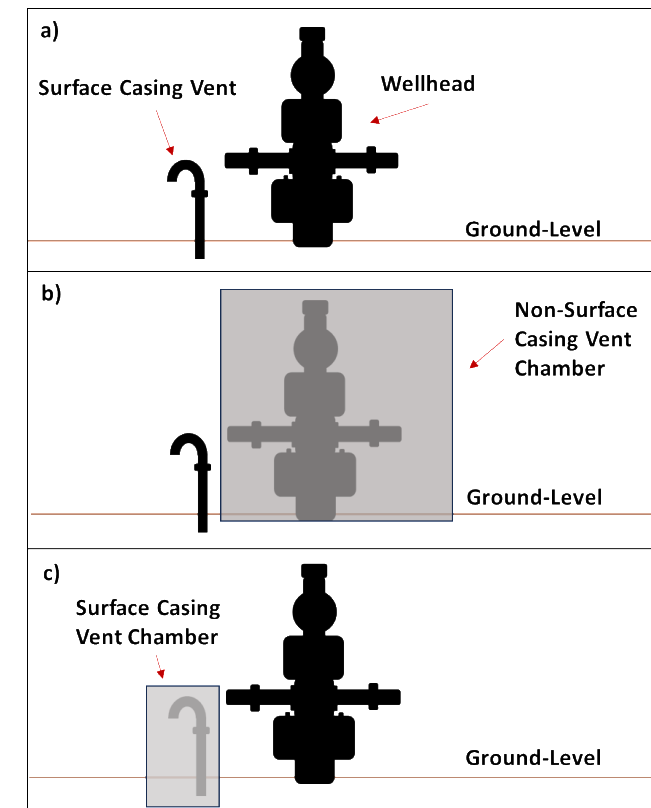
**+ Geochemical Analysis in the Lab**

# Methane emission rates are driven by multiple processes

**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.



→ *Separately measure SCV and wellhead emissions*

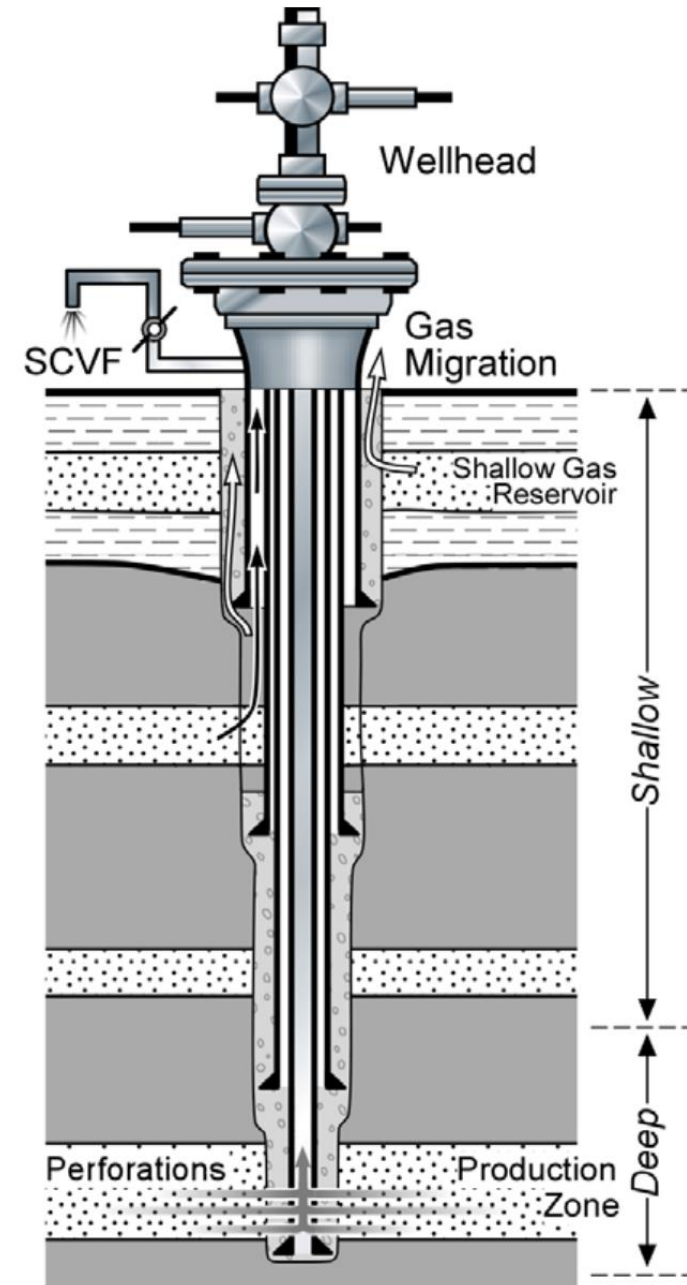


Bowman  
et al.  
(2023)



# Role in national emission inventory estimates

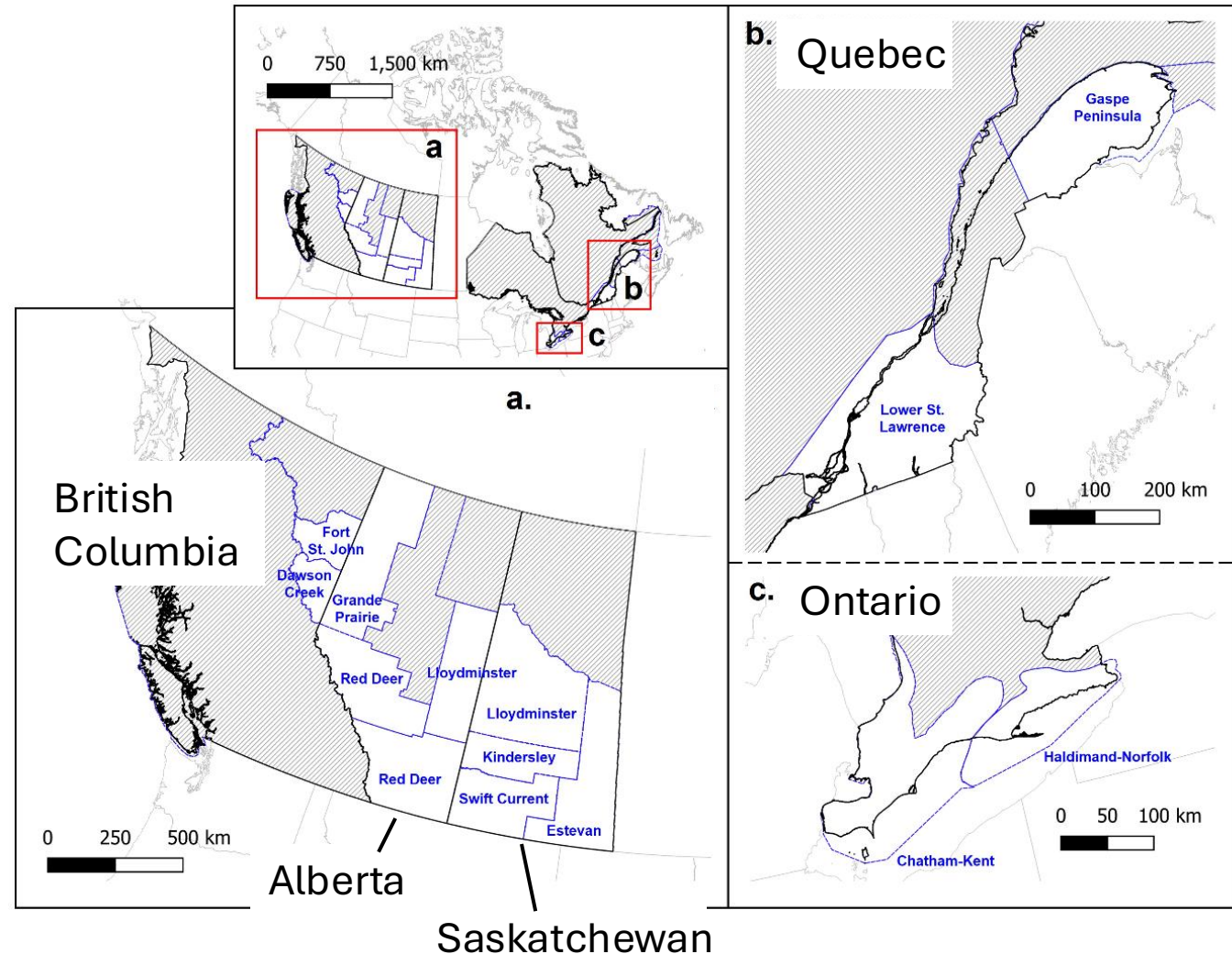
- In Canada, methane emissions estimated separately for surface casing vent flows (SCVFs) and wellheads.
- In the U.S., SCVs are generally closed and methane emissions for SCVFs are not explicitly estimated. SCVF emissions may be captured indirectly.



Watson and Bachu (2008)

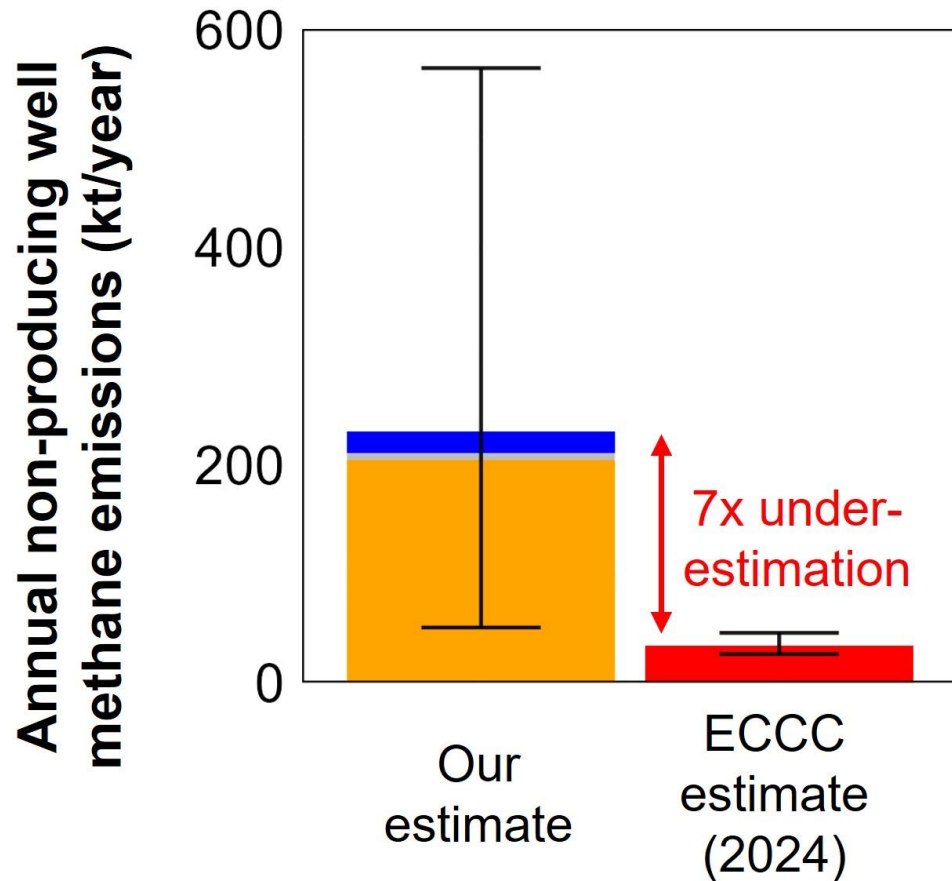
# 494 non-producing wells measured across 5 provinces in Canada

- Geographical variation consistently shown to be a predictor of high emitters (El Hachem and Kang, 2023).
- Also considered well type, well status, and plugging status
- Well selection not based on reports of high emissions or SCVF/GM database





# Sevenfold underestimation in non-producing well methane emissions in Canada

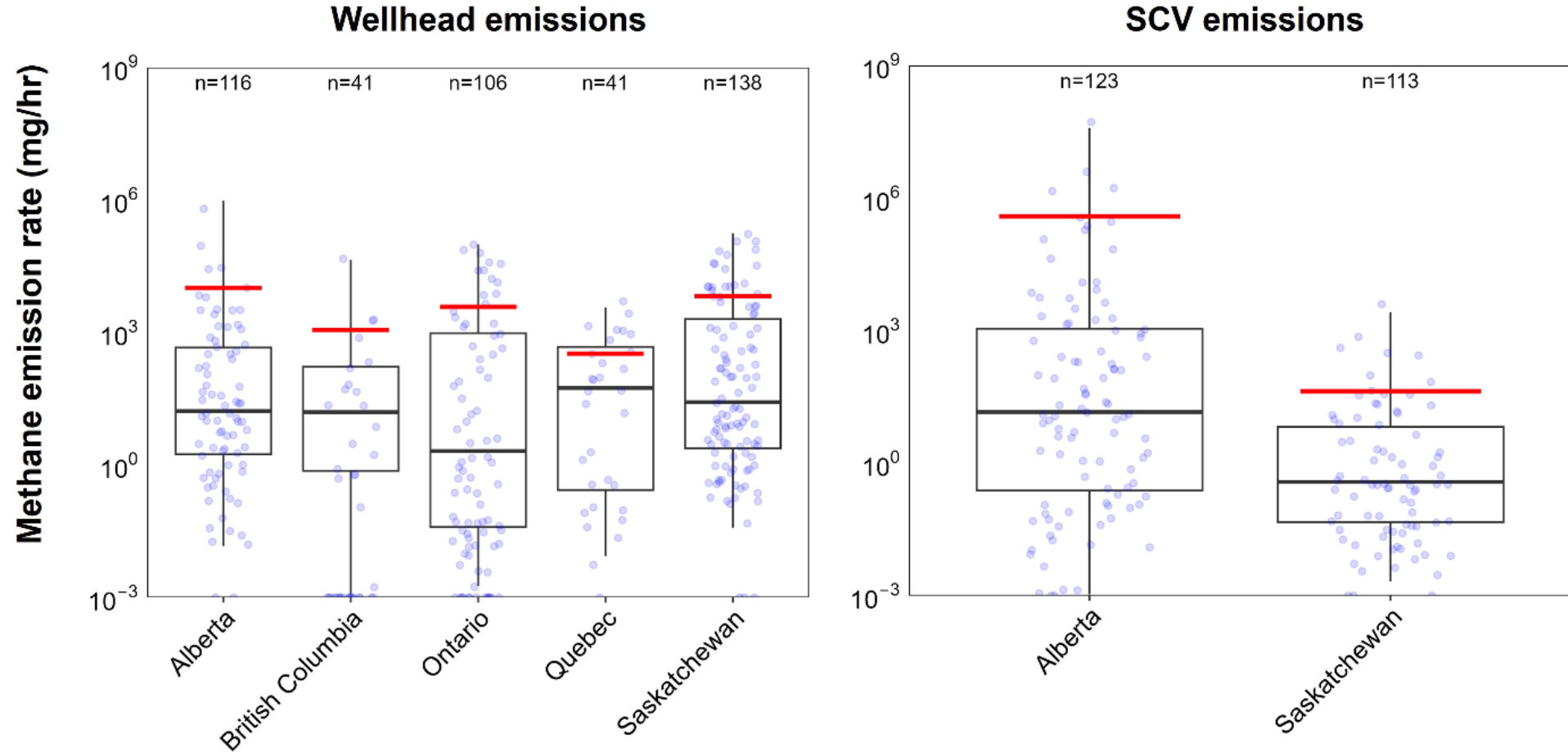


Non-producing well emissions are 13% of total currently estimated fugitive oil and gas methane emissions in Canada.

*Why were the emissions so underestimated?*

# Large range in methane emission rates

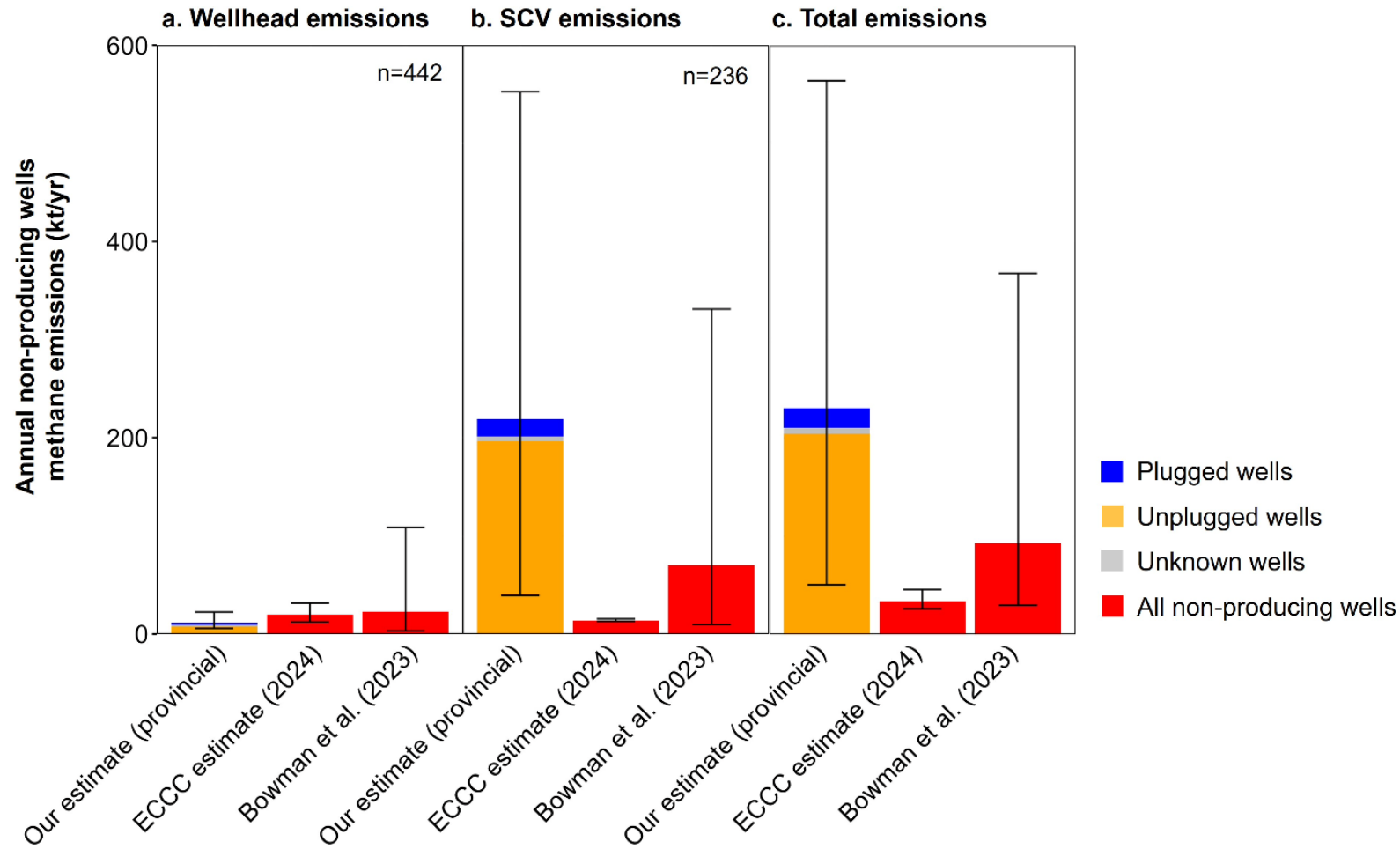
→ New highest emission rate of 39 kg/hr at an SCV



— Mean emission rate (Emission factor)



# Non-producing well emissions underestimated because of SCV emissions from unplugged wells



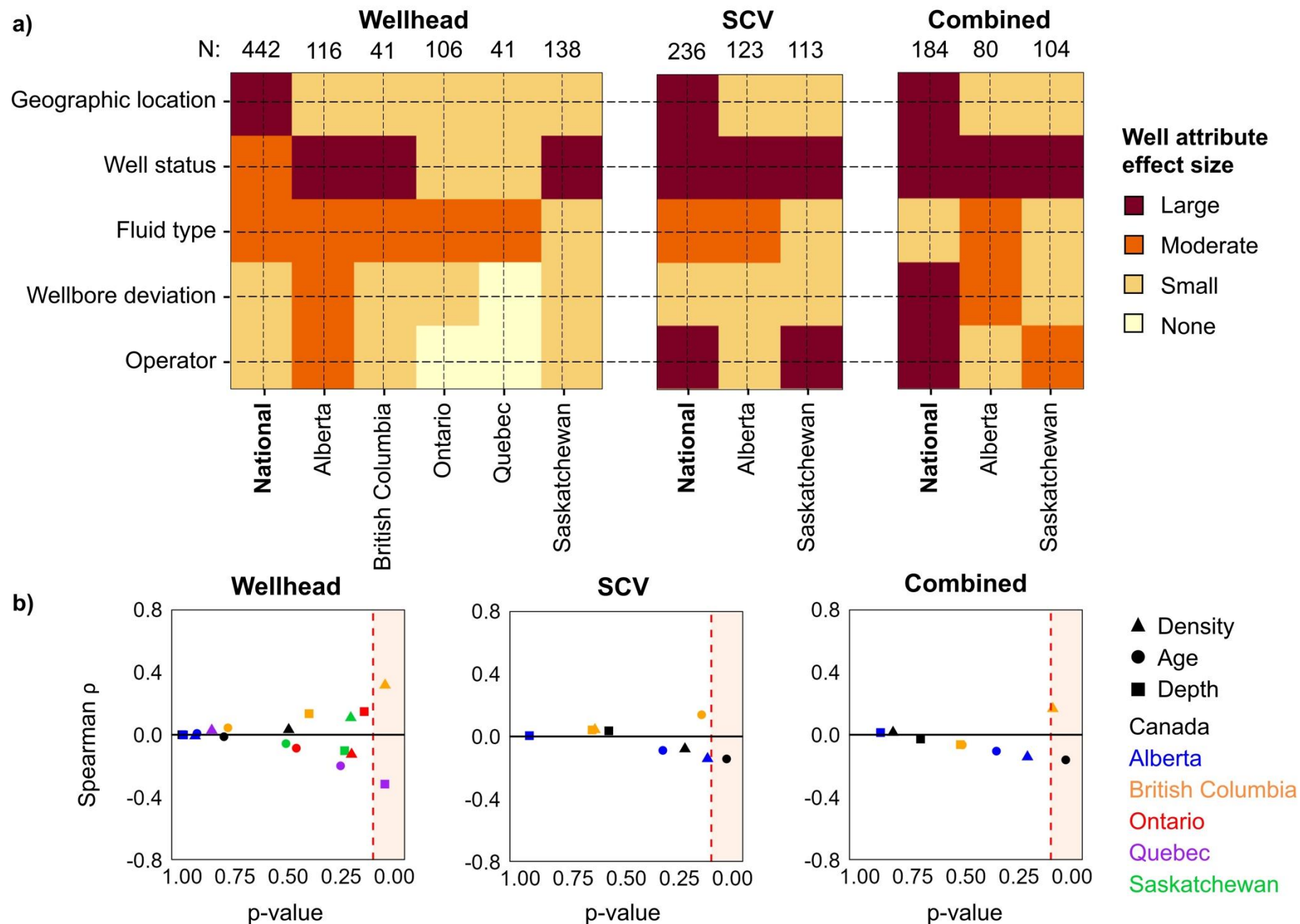
*Uncertainty in emission estimates largely driven by emission factor uncertainties.*

*→ Need representative measurement datasets*

# How do we get a representative sample?

Role of well attributes vary with province and component

Klotz et al. (2025)

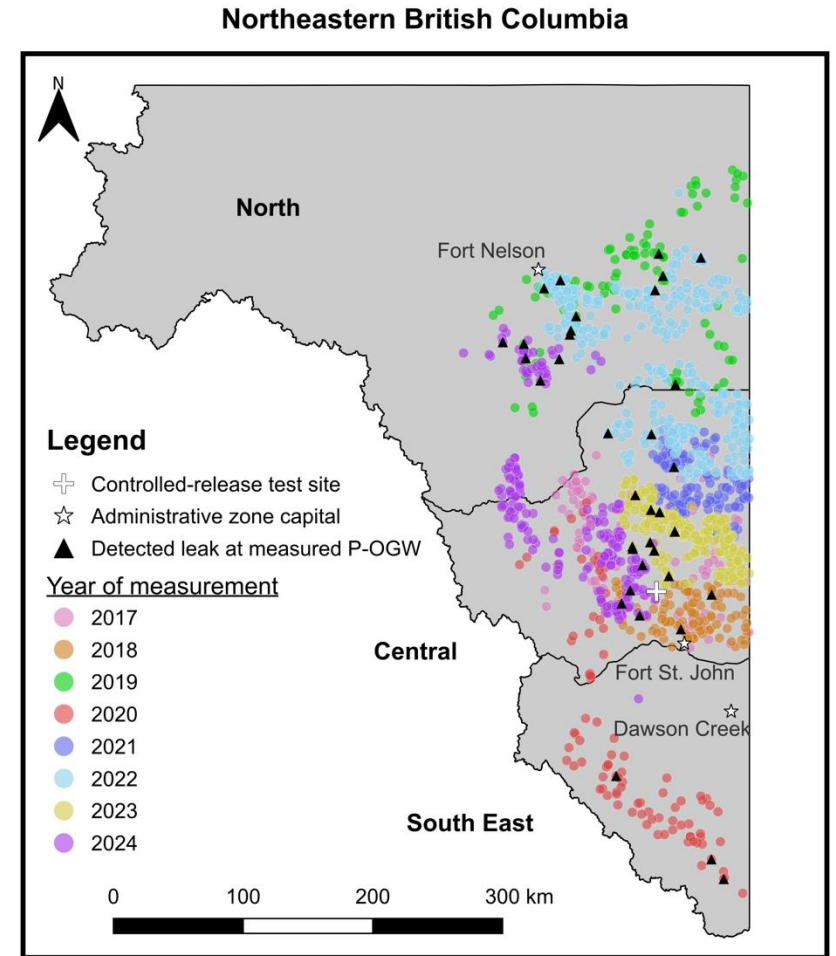


# How can we better estimate the proportion and rates of high emitters?

The British Columbia Energy Regulator (BCER) has been commissioning annual helicopter surveys of their plugged wells since 2017.

1,410 plugged wells surveyed from 2017 to 2024.

Methane detections provided as: “Not detected”, “Small”, “Medium”, and “Large”

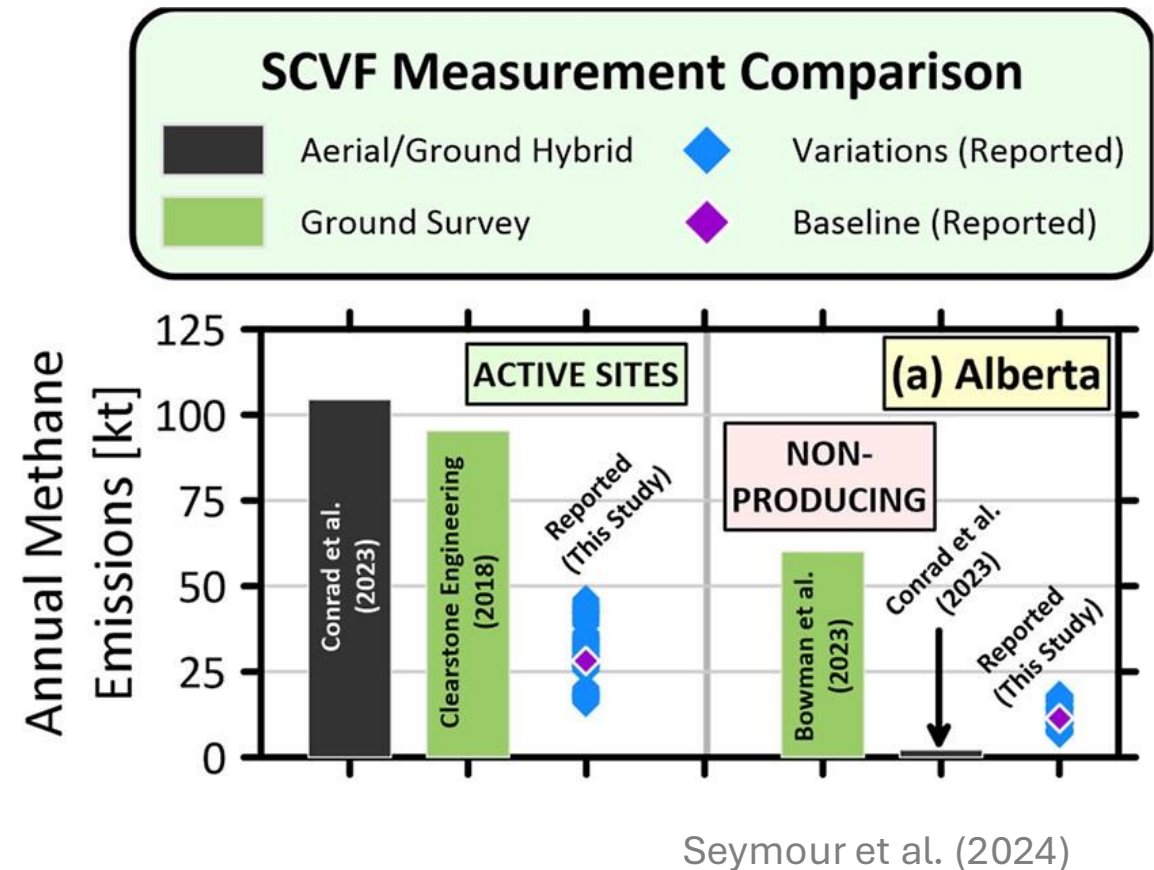


Woolley and Kang (In Prep)

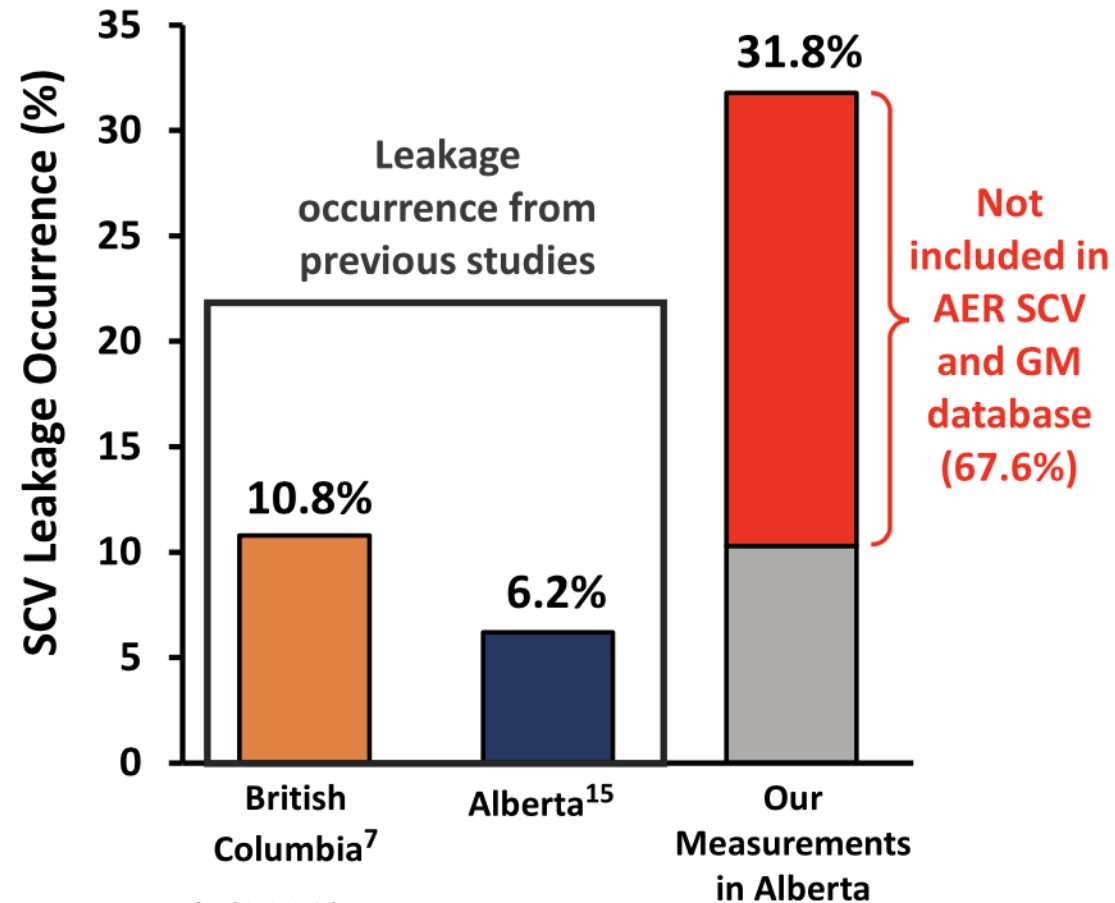


# Measurement methods (aerial/ground/hybrid) and assumptions

- Some aerial/ground hybrid methods do not capture non-producing well SCV emissions
- Even using the same data source (SCVF/GM reported to provinces), emission estimates vary with
  - Assumptions on repair timelines
  - Treatment of missing data
  - Gas composition
  - ...



# Challenges to using available SCVF data: gaps and temporal variations?

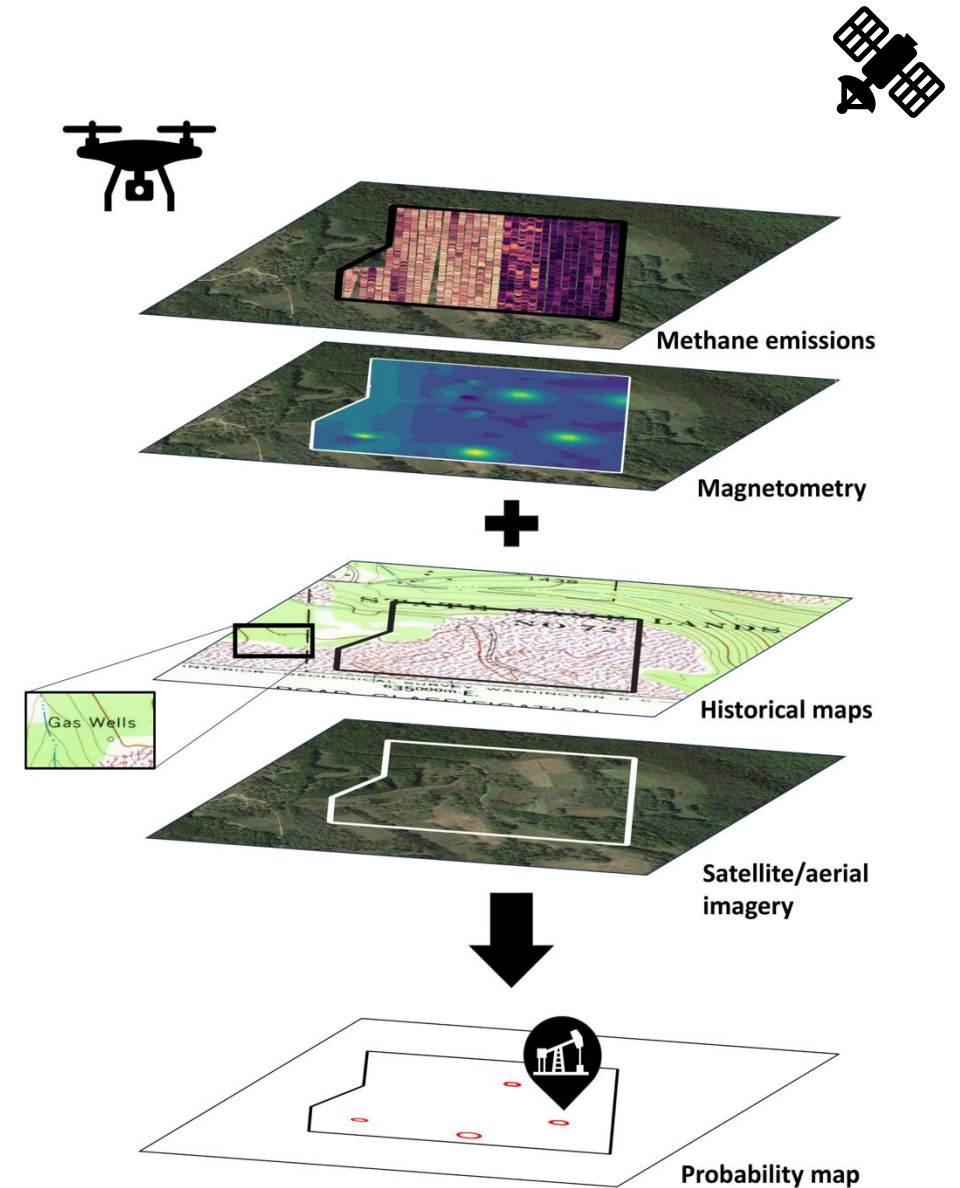


Bowman et al. (2023)

# Could there be a significant number of undocumented wells?

“Undocumented orphan wells (UOWs) are wells for which no documentation exists, possibly including their locations. There likely exists many UOWs that are completely unknown to State or federal officials.” (O’Malley et al., 2024)

- ~300,000-800,000 UOWs in the U.S. (IOGCC, 2021)
- ~30,000 UOWs in Canada (Klotz et al., 2025).

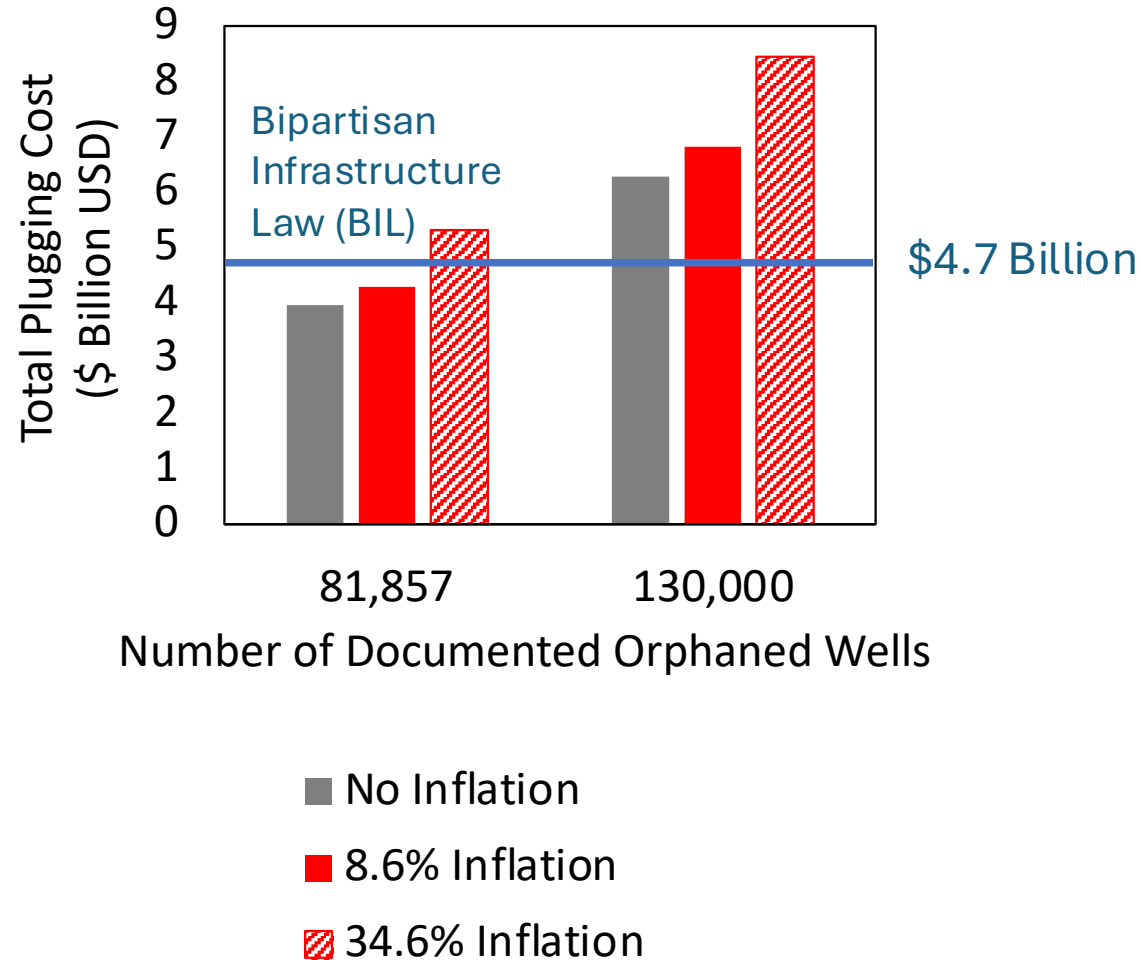




# What do we do about these wells?

Well plugging and costs

# Total plugging costs for orphaned wells in the U.S. exceed federal funding

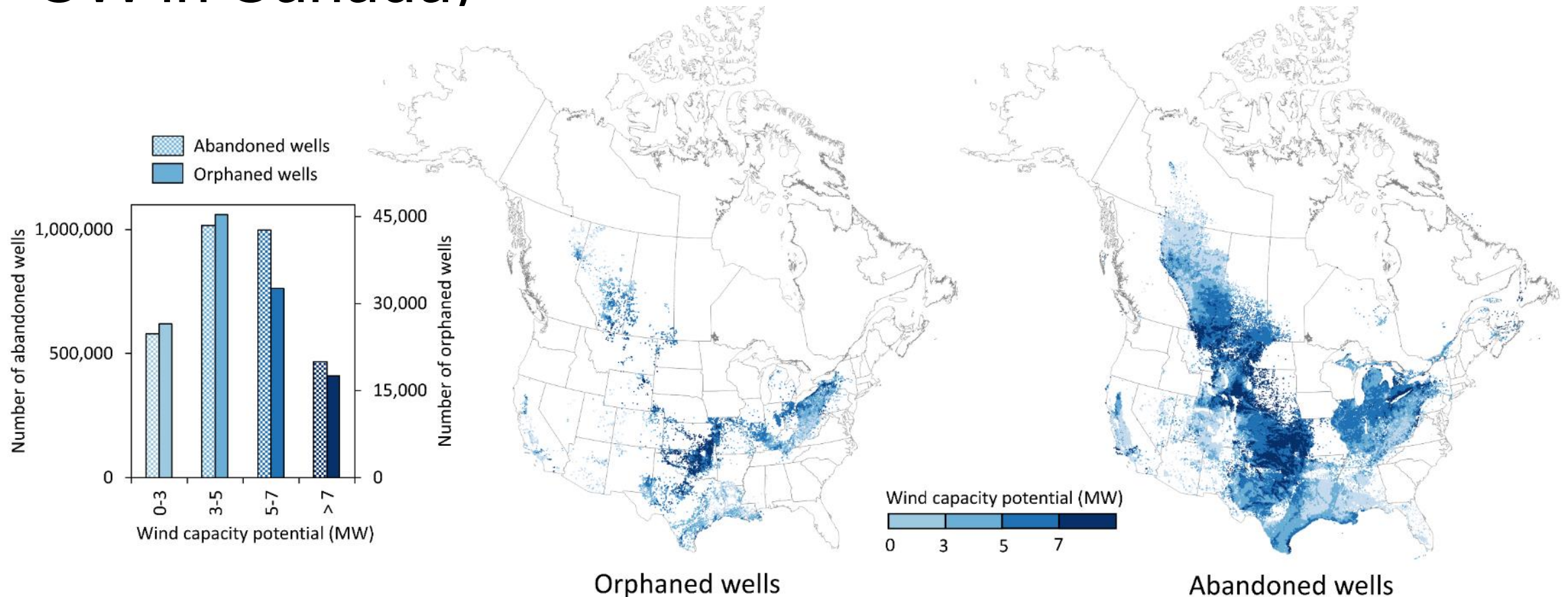


# Are there opportunities to repurpose non-producing wells?

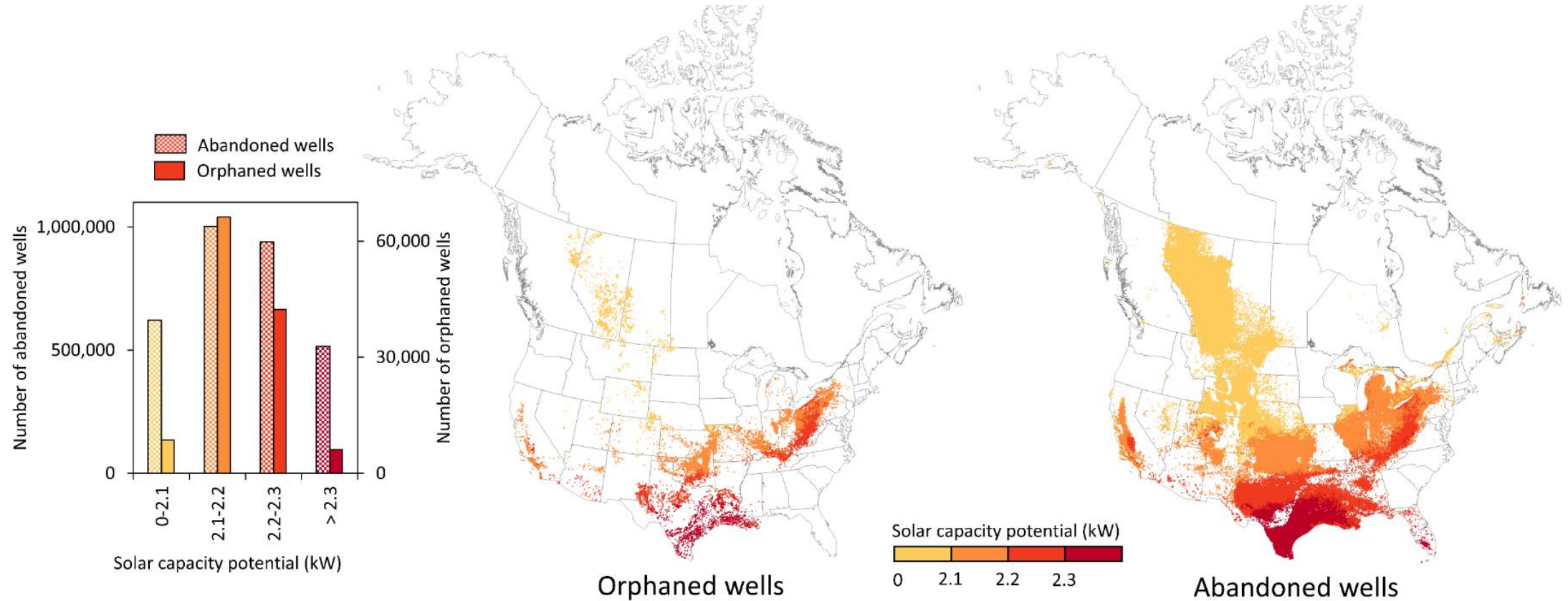
Renewable energy: wind, solar, geothermal...



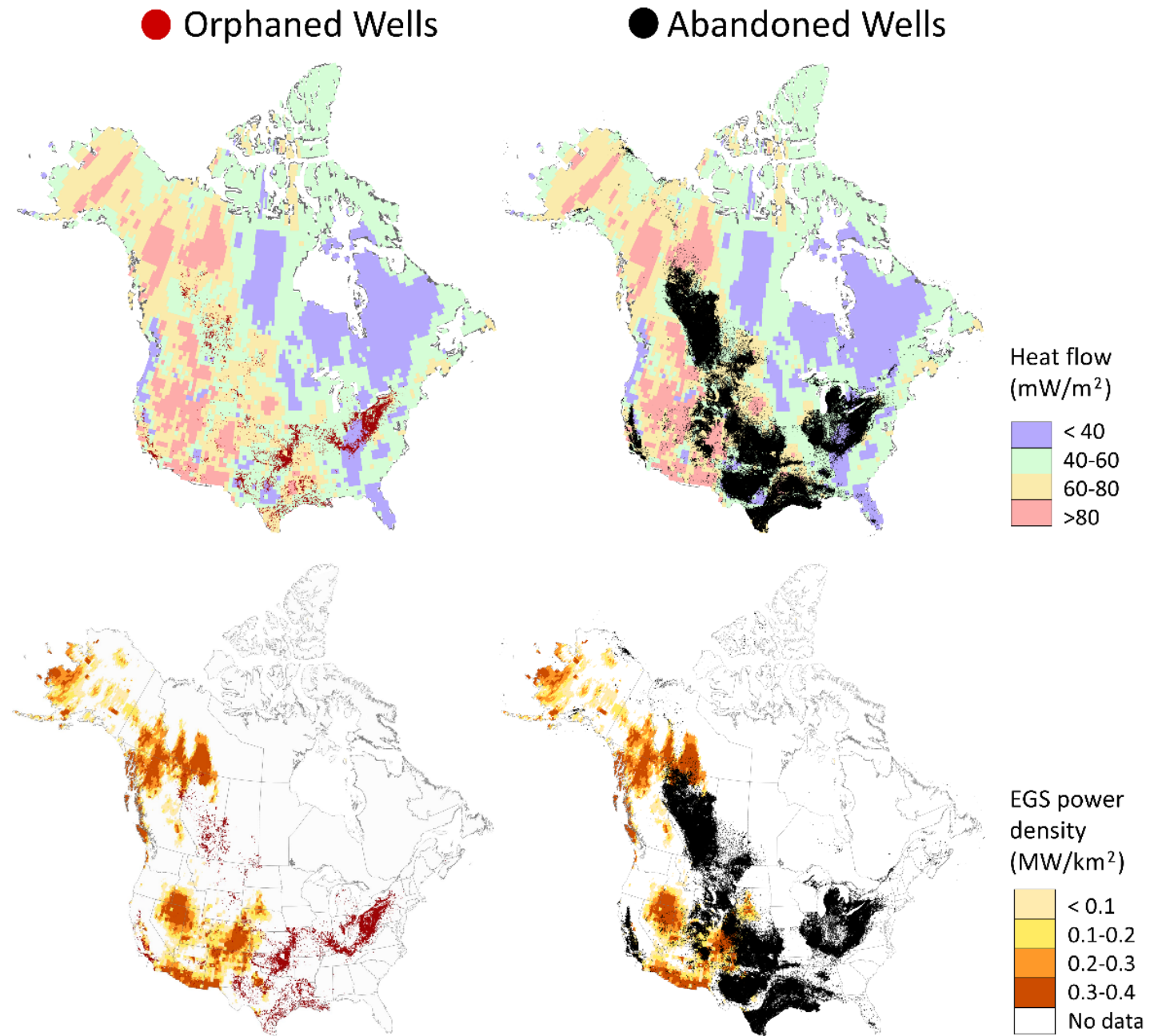
More than 15 terawatt of wind capacity across abandoned and orphaned well sites, far exceeding current installed capacity (150 GW in the U.S.; 15 GW in Canada)



# Solar capacity at abandoned and orphaned well sites could boost current solar capacity by more than 5%



>90% of abandoned and orphaned wells have depths suitable for shallow geothermal systems, yet deep geothermal possible at up to 10% of wells





# Key takeaways

- Non-producing well methane emissions are underestimated in Canada and likely elsewhere.
- SCV emissions from unplugged wells in Alberta dominate non-producing well methane emission estimates for Canada.
- Unclear if we have a representative measurement dataset but recent studies indicate emission factors may be higher than what is currently used in national inventories.
  - Opportunities to use multi-scale measurements.
- Could there be a significant number of undocumented wells in Canada (and elsewhere)?
- “Repurposing oil and gas wells can help fulfill national energy transition goals and emission reduction targets, while providing an additional funding stream to manage their environmental risks.” (Boutot and Kang, 2025)

# Thank you!

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

Associate Professor, Canada  
Research Chair (T2) in Environmental  
Monitoring and Energy Transition

Civil Engineering, McGill University

[mary.kang@mcgill.ca](mailto:mary.kang@mcgill.ca)



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