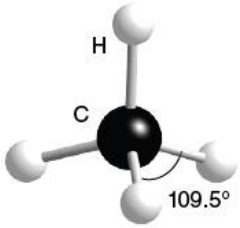

Calculating Orphaned Well Methane Emissions

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TEAM KENTUCKY
ENERGY AND ENVIRONMENT CABINET

Orphaned Oil and Gas Wells (OOGWs)- Local Impacts

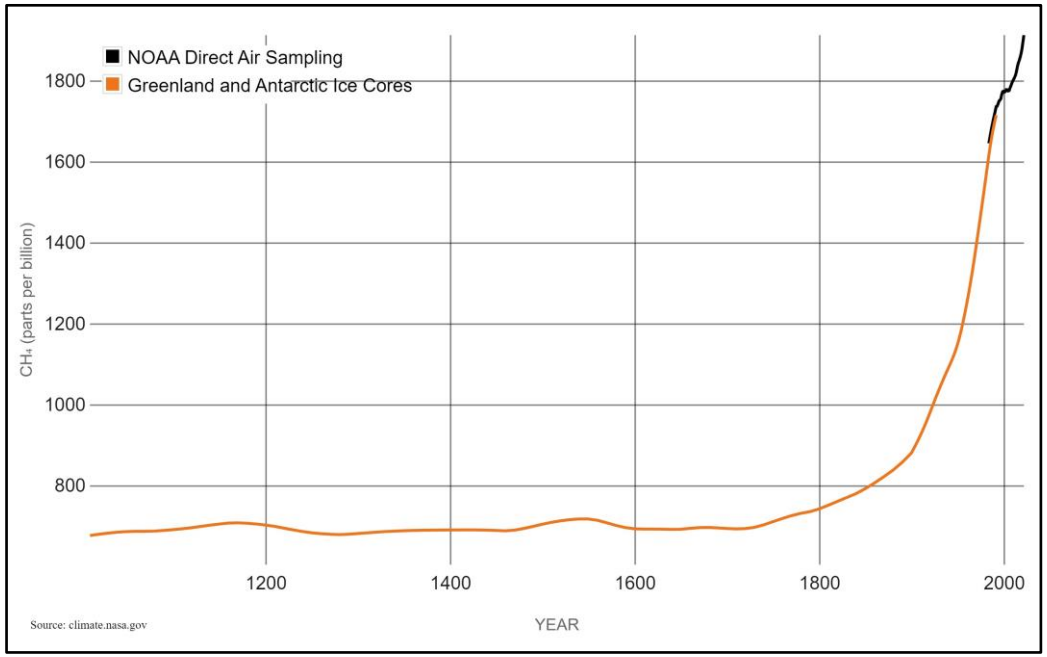
OOGWs are potential environmental hazards at different scales in time and space:

1) Near-term and local threat to groundwater and soil
2) Surface hazard for recreation and work

Permit #N24767, Rockcastle Co.
Comp. gas well 12/1965
3.82 g/hr

(OOGWs)-Global Impacts

Permit 33741, Grayson Co.
Completed gas well (08/1978)
H_2S up to 88 ppm



- ~2.4X increase since 1750
- ~20 to 30% global warming
- Precursor compound for ozone
- Atmospheric lifespan 7-12 years

Bipartisan Infrastructure Law and the DOI Orphaned Well Program

Challenge: 150 years of domestic oil and gas development has left legacy of **~3.5 million** abandoned oil and gas wells.

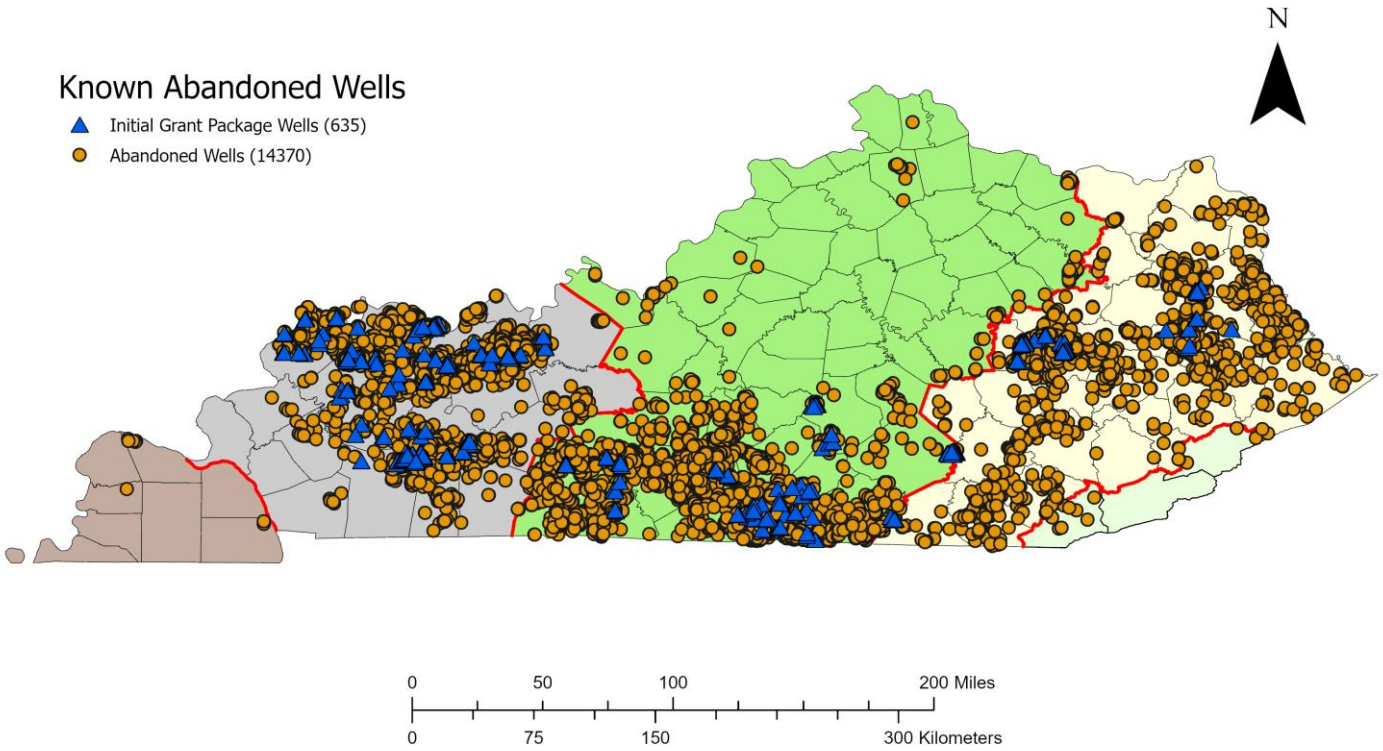
Solutions via the Bipartisan Infrastructure Law:

- 2021 BIL provided $4.7 billion to the U.S. Department of Interior to plug orphaned wells and establish inventories for future plugging
- Funds to be distributed among three programmatic areas: (1) federal lands, (2) tribal lands, and (3) state lands.
- State program includes three grants: (1) Initial—$5 billion, (2) Formula—$2 billion, and (3) Performance—$1.5 billion

U.S. Department of the Interior

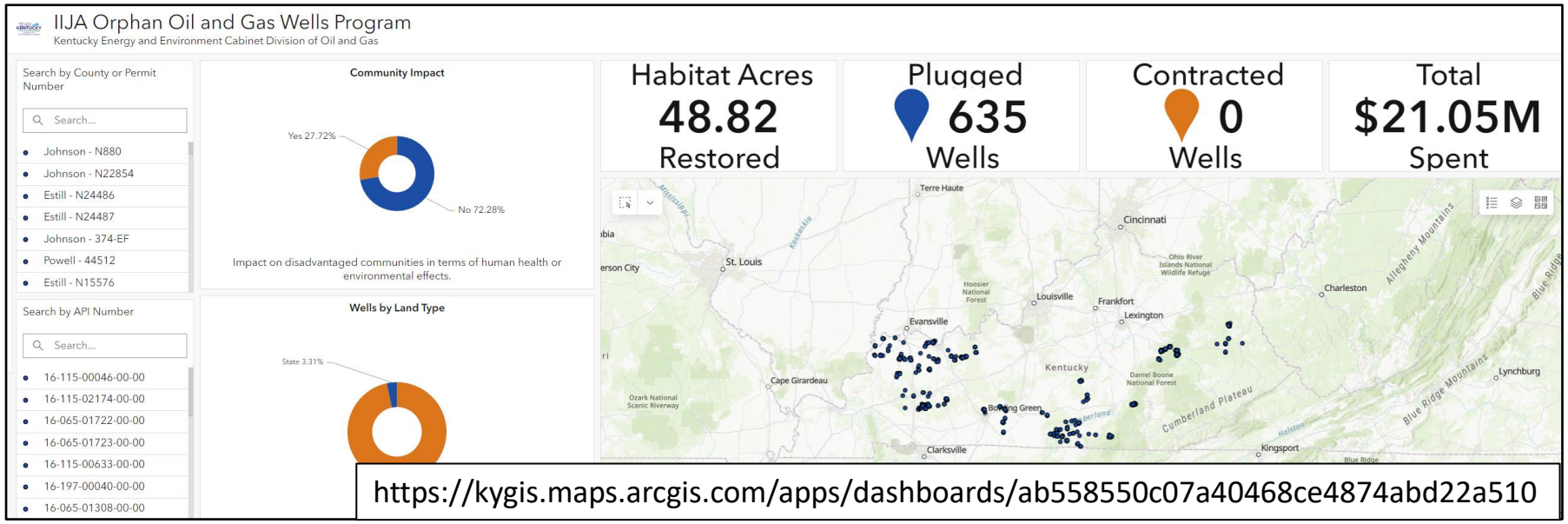
https://www.doi.gov/orphanedwells

Kentucky Energy and Environment Cabinet Division of Oil and Gas (KDOG)



- BIL funding provided generational opportunity for state to plug many of the known 14,000 abandoned oil and gas wells
- To date, KDOG has received two grants: (1) $25 million under the Initial Grant Program (10/01/22-09/30/27) and (2) $25 million under the Formula Grant Program (05/01/24-04/30/29).

KDOG Initial Grant Program



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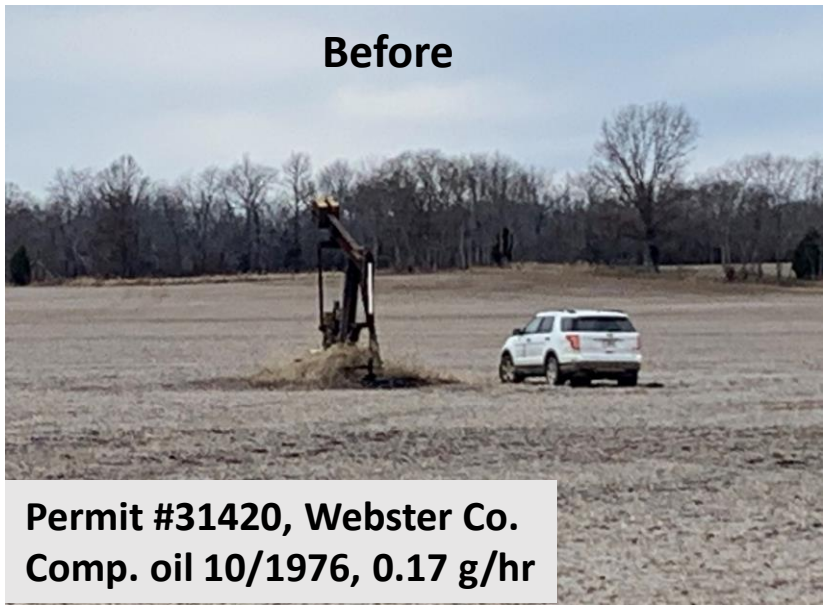

Permit #31420, Webster Co.
Comp. oil 10/1976, 0.17 g/hr

Methane and KGS Collaboration

The Bipartisan Infrastructure Law directed the Secretary of the Interior to establish programs to inventory and properly close orphaned wells. The Law provides $4.7 billion for orphaned well site plugging, remediation and restoration activities on federal, Tribal, state and private lands. This historic investment will reduce methane and other greenhouse gas emissions from orphaned wells, help clean up water contamination, restore native habitat, create good-paying union jobs and benefit disproportionately impacted communities. The Department prioritizes a coordinated and unified whole of government approach to environmental justice issues and supports the Administration's Justice40 Initiative, a whole-of government approach to advancing environmental justice.

https://www.doi.gov/orphanedwells

- **Measure methane emissions: ongoing with 94 wells measured**
- **Develop statistical model for prediction of emissions behavior by well subtype**
- **Develop prioritization tool for plugging OOGWs that incorporates factors specific to orphaned wells and their geospatial setting**
- **Post-plugging measurements on subset of plugged wells**

Collaborations with KDOG

#922WF, Union Co., 2.14 g/hr

#76200, Rockcastle Co., 2.46 g/hr

- Lead individuals for finding abandoned wells in the field and administrative sleuthing
- Establish landowner contacts
- Develop packages of wells for plugging
- Methane screening measurements
- Keep KGS from being lost

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Estimating Methane Emissions

- In theory, measurement is straightforward as methane emissions equal:

Total gas flow rate X Methane concentration

#32232, Clinton Co.
0.00003 g/hr

- In reality, varied legacy infrastructure, accessibility, terrain, and emissions magnitudes require diverse measurement approach

#N17603, Daviess Co.
605 g/hr

Ventbusters—Well Done Foundation

#922WF, Union Co.
Comp. Miss oil 08/1950, TVD 1821 ft
2.14 g/hr

- Measured 47 wells in 16 counties (02/2023-08/2023)
- High sensitivity flow meter (0.04 mL/min) measured total gas flow from well through chamber or direct connection to port on well
- Total gas flow rate measured and recorded over extended period (~8 to 72 hours)
- Gas sample collected at end of test analyzed for methane concentration
- Pros: unattended testing, long-term tests, large potential emission range (10^{-2} to 10^{3} g/hr).
- Cons: assumes methane concentration constant over test, limited application to complex wellheads, lack of portability

Chamber Measurements

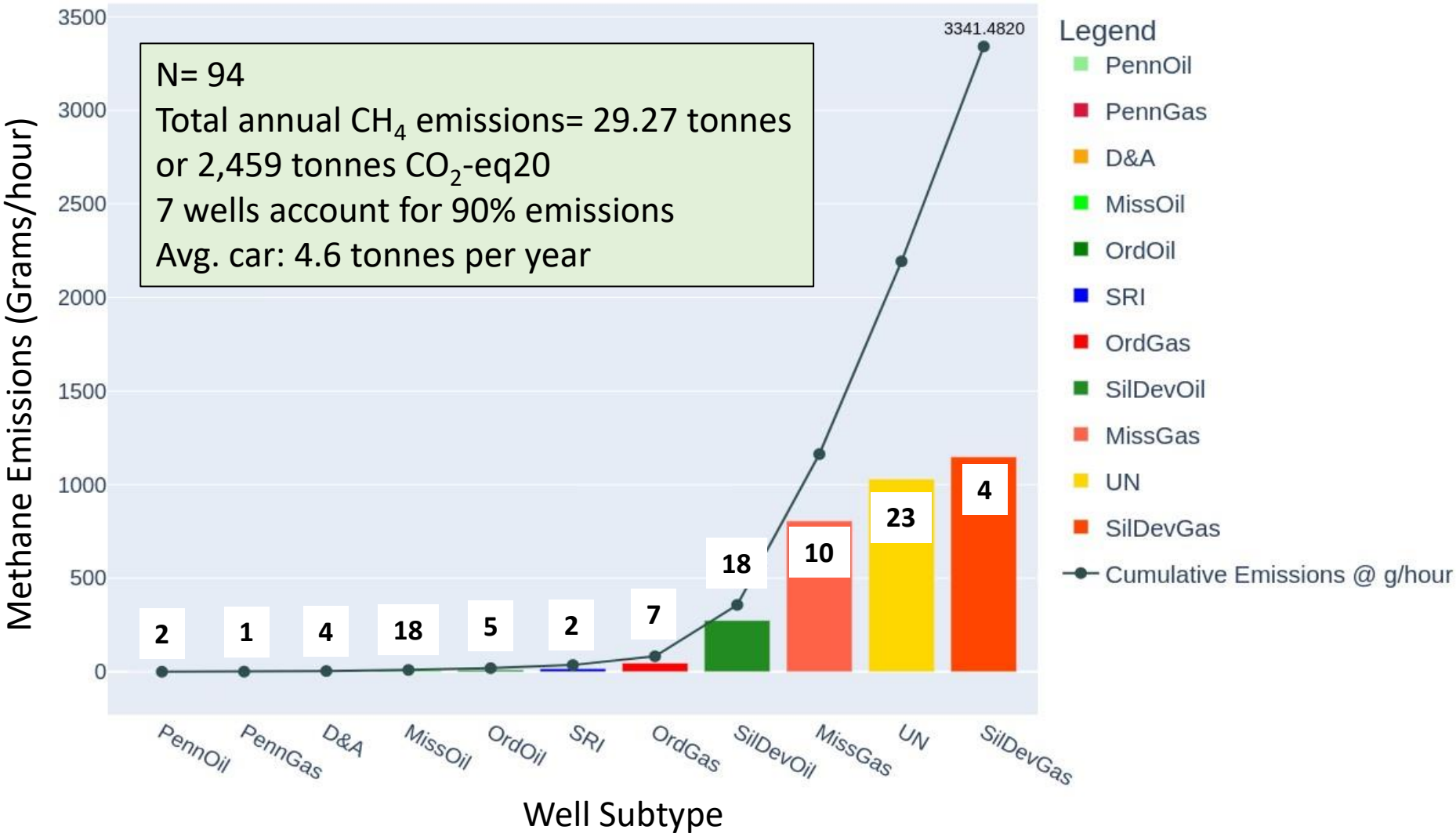
#2504, Lee Co.
Comp. Sil SRI 05/1961, TVD 856 ft
0.021 g/hr

- Traditional way to measure gas exchange between soil and atmosphere modified to enclose wellhead
- Measured 7 wells in 4 counties (01/2024-05/2024)
- Measure change in methane concentration over time inside the enclosed chamber
- Slope equals emission rate which is calculated for the chamber volume.
- Pros: background theory straightforward, accurate measurement at low emission rates (<1 g/hr), document variation in methane concentration real-time
- Cons: wellhead must fit inside chamber, static chamber limited to low emitting wells, lack of portability

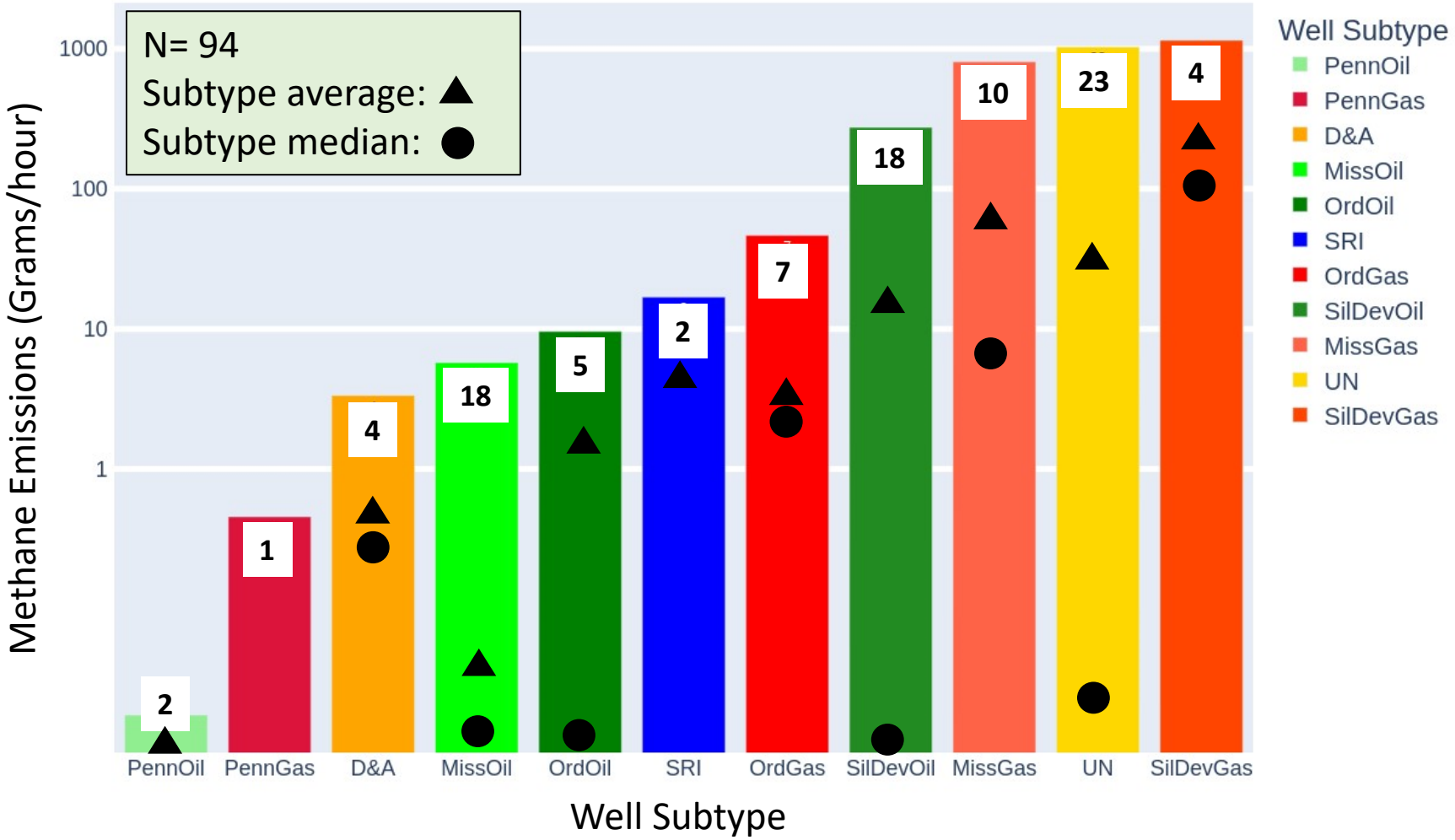
SEMTECH High-Flow 2 Sampler

- Portable sampling device/technology platform that accurately measures methane leakage by extractive dilution and gas concentration measurement
- Consists of (a) high-flow fan and Pitot-based flowmeter that dilutes the leakage plume at a known rate, and (b) gas analysis bench that contains a tunable diode laser absorption spectrometer accurate to 1 ppm.
- Well with multiple leak points can be tarped for measurement
- Measured 40 wells in 8 counties (11/2023-06/2024)
- Pros: adaptable to different wellhead configurations, large measurement range (1 to 10^4 g/hr), portable, friendly user interface
- Cons: complex foundation theory, accuracy questionable at low emission rates

Methane Emissions Distribution



Methane Emissions Distribution—A Closer Look



Summary and Looking Ahead

Ashland Cable #1, #60010, Lee Co.
Comp. Ord Gas 04/1984, TVD 9,649 ft
28 g/hr

- Gas well subtypes tend to be higher methane emitters as compared to oil well subtypes
- SilDevOil, OrdOil, and UN well subtypes show greater fat-tailed distributions
- Continue to improve robustness of statistical model with measurements on Phase 1 target wells many of which are proxies for Initial Grant wells.
- Better understand factors influencing emission variability within subtypes (e.g. Infrastructure openness).