

Identifying and Quantifying Emissions from Abandoned and Orphaned Oil and Gas Wells

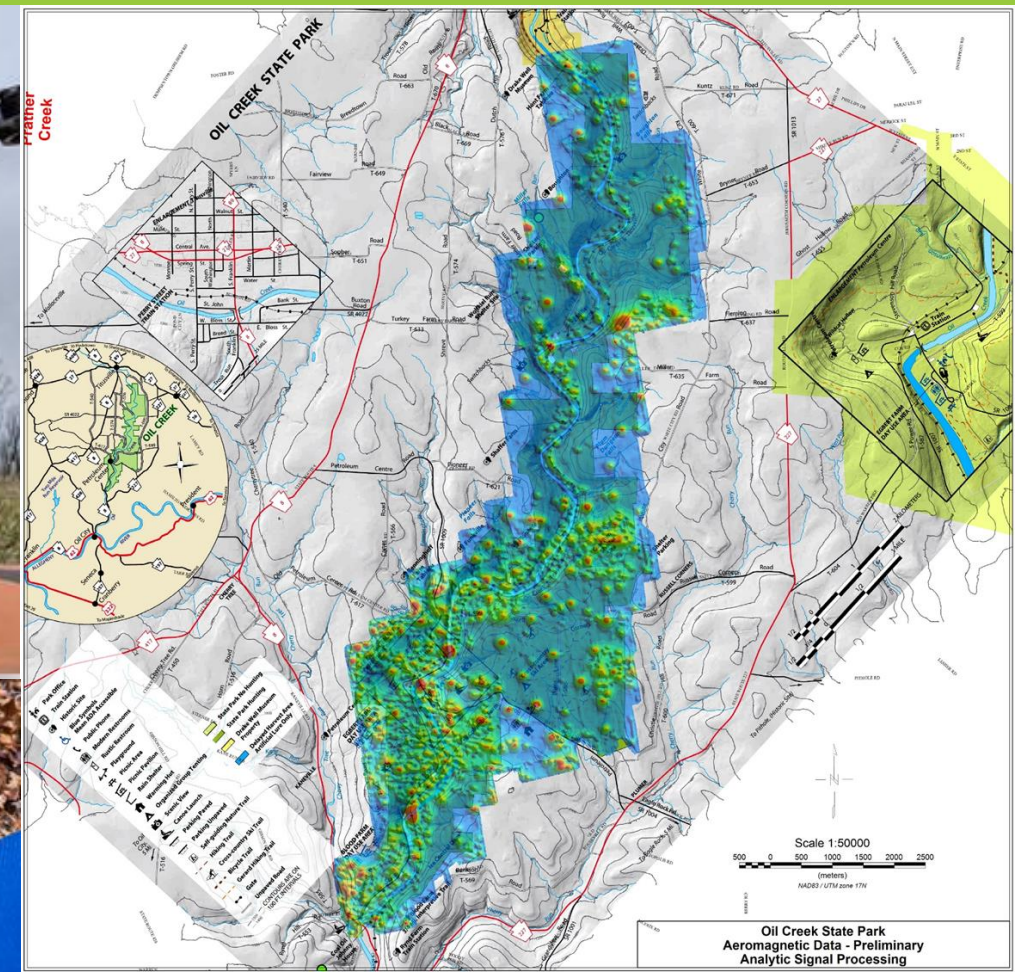
HEI – Energy Webinar: Human Exposure Research in a Cyclical Industry: Abandoned and Orphaned Oil and Natural Gas Wells

November 30, 2021



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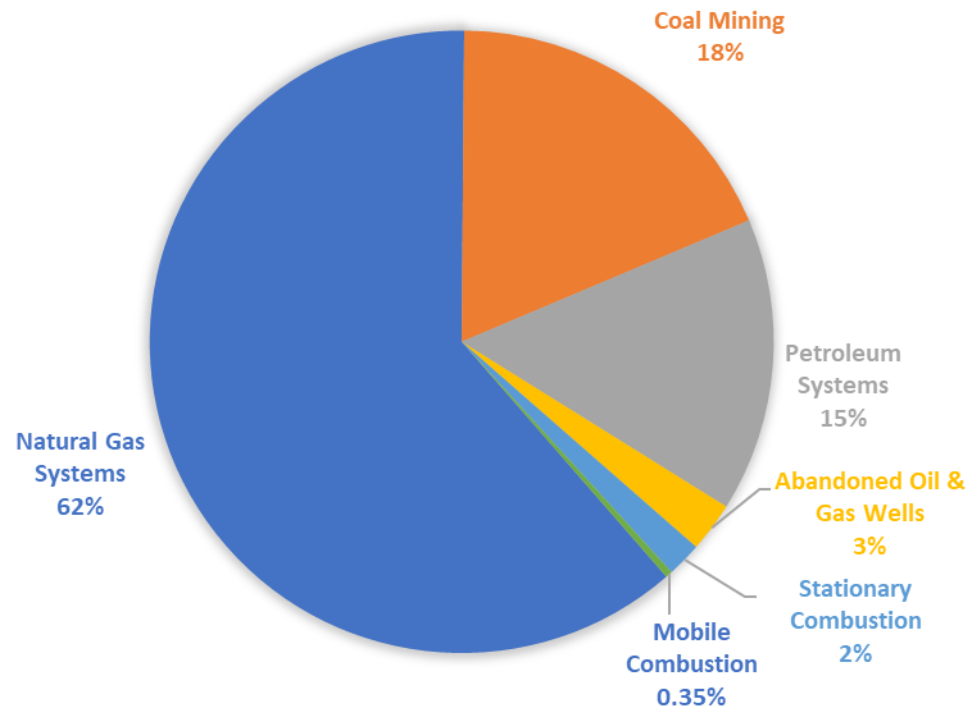
Acknowledgement: This technical effort was performed by and in support of the National Energy Technology Laboratory's ongoing research under the Natural Gas Infrastructure Field Work Proposal DOE 1022424.

Methane Emissions from Natural Gas Infrastructure

U.S. EPA Greenhouse Gas Inventory (2021)

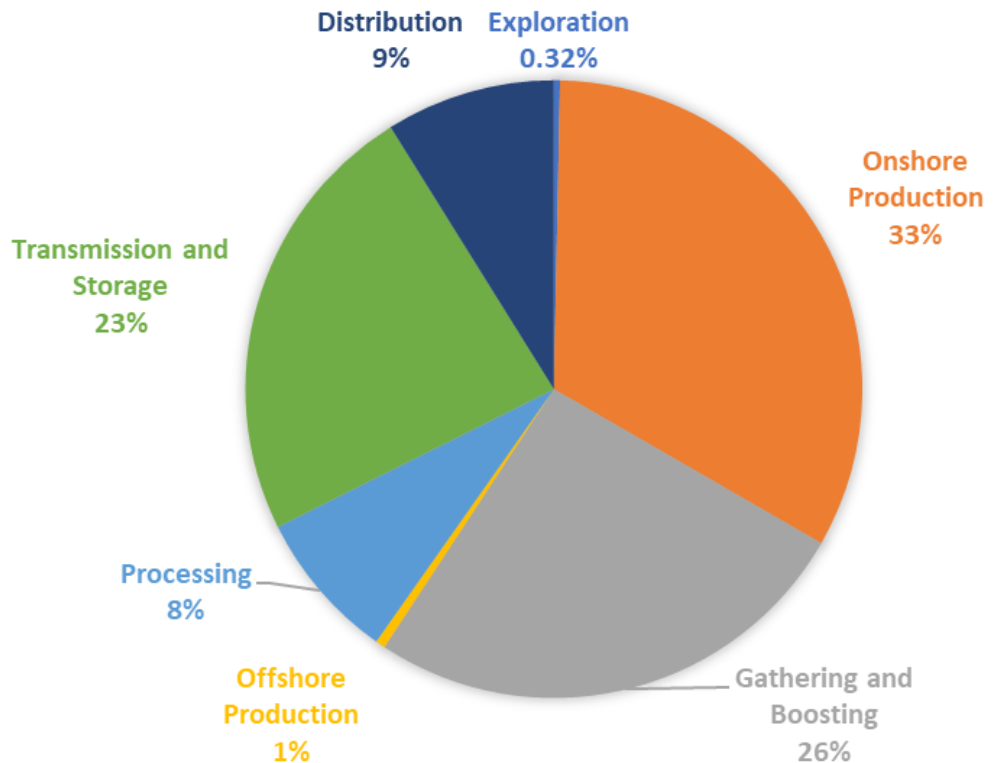
Methane Emissions from Energy

Total Methane: 256.2 MMT CO₂ Eq



Methane Emissions from Natural Gas Systems

Total Methane: 157.6 MMT CO₂ Eq



Methane Emissions from Abandoned Oil and Gas Wells

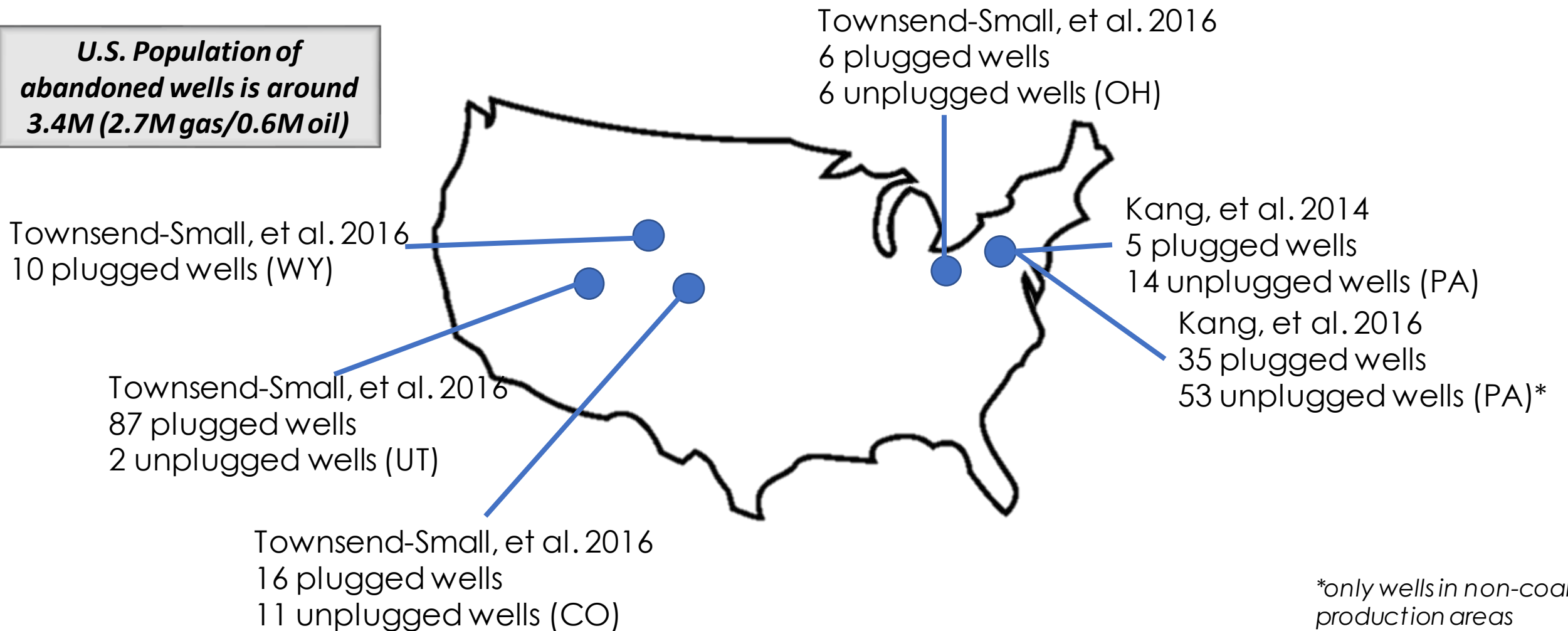
Classifying and Inventorying Abandoned Wells

- The US EPA began including abandoned wells as a GHG Emissions source in 2018 (2016 GHGI)
- From the Inventory:
 - 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.
- The GHGI estimates methane emissions from abandoned wells by multiplying **emission factors** (mass of methane emitted per well) by **activity levels** (number of wells)
 - Significant uncertainty in both EFs and ALs

Abandoned Well Methane Emission Factors

Sample Size and Distribution Across the US

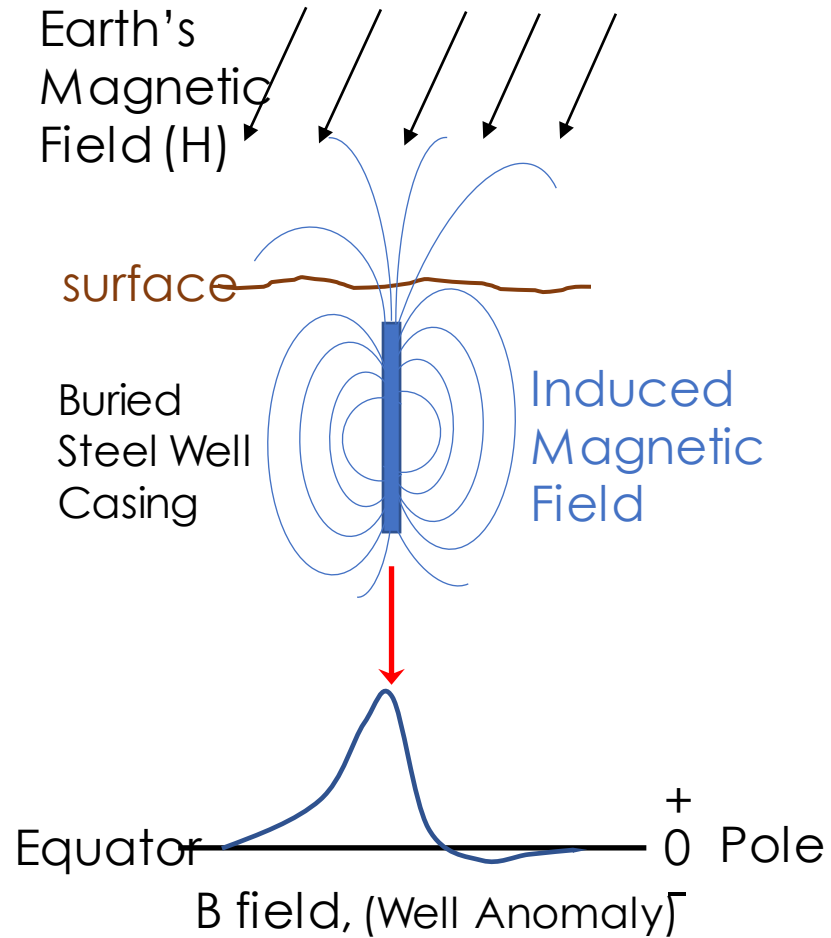
***U.S. Population of
abandoned wells is around
3.4M (2.7M gas/0.6M oil)***



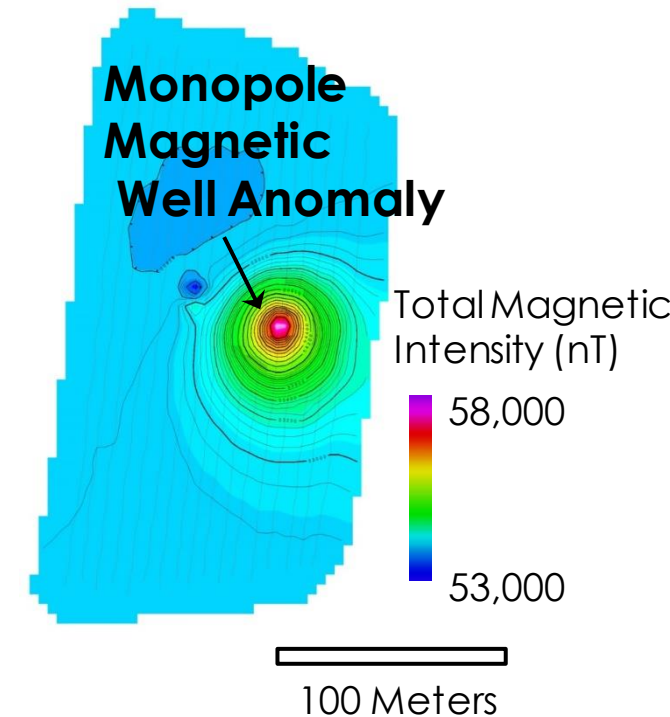
**only wells in non-coal
production areas
included in the EFs*

Locating Wells Using Magnetic Signature

Unmarked Abandoned Wells



**Locating and Verifying
Unmarked Legacy Wells**



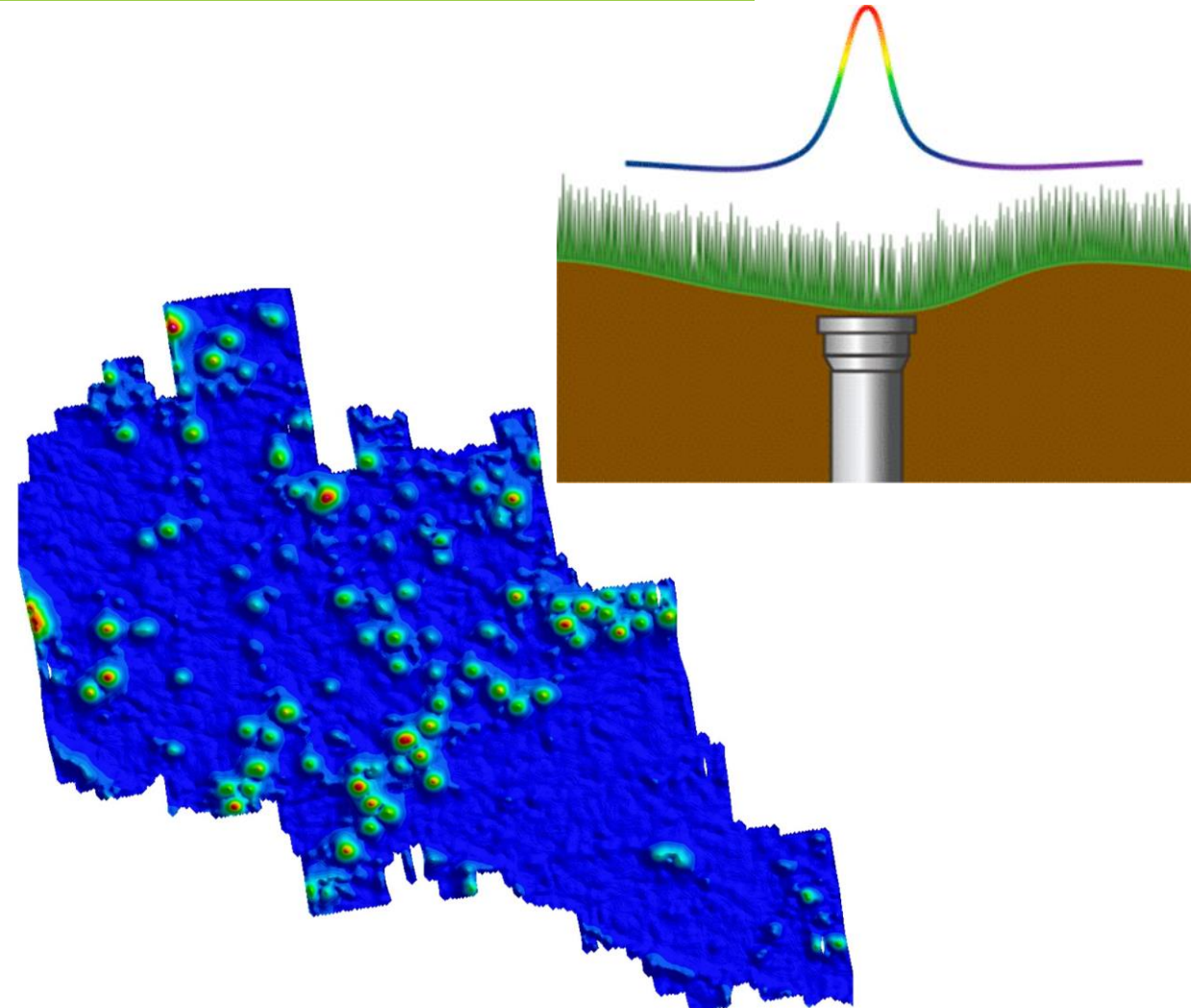
**Ground Magnetic
Survey**

Methane Emissions from Abandoned Oil and Gas Wells

Activity Level: Estimating Number of Wells

- History of success using aeromagnetic surveys to find wells
 - Magnetic surveys identify 46 - 59% more wells than recorded in state and national databases
- Estimated total number of wells
 - PA: 395,000-466,000
 - WY: 181,000-182,000

Extrapolating to U.S.: 6.04 ± 19.97 million wells with 1.16 ± 3.84 designated as abandoned



Methane Emissions from Abandoned Oil and Gas Wells

Emission Factor: Estimating quantity of methane coming from a typical well

- Methodology: Directly collect methane emission rate measurements from wells using
 - Laser-based sensor
 - Optical gas imaging (FLIR GF-320)
 - High Flow sampling
 - Gas composition analysis



Methane Emissions from Abandoned Oil and Gas Wells



Emission Factor Results

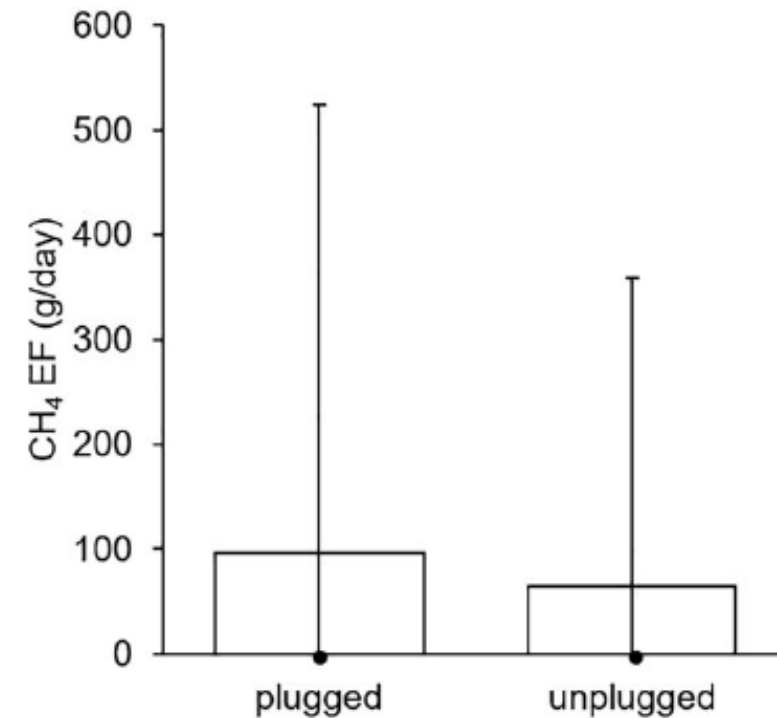
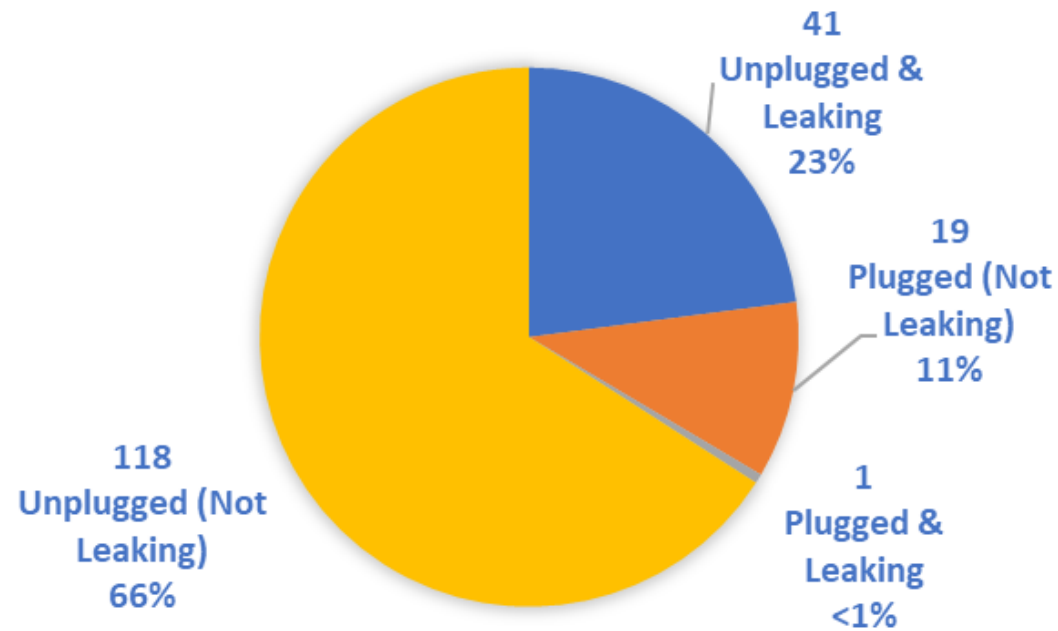
- Pennsylvania
 - Hillman State Park: 31 wells, all unplugged, average emission rate for 22 not buried wells was 0.7 kg CH₄/day
 - Oil Creek State Park: 138 wells, 67 unplugged/71 plugged, 10 unplugged wells were leaking with an average emission rate of 0.29 kg CH₄/day
- Oklahoma: 179 wells, 159 unplugged/20 plugged, unplugged average emission rate of 0.065 kg CH₄/day; plugged 0.096 kg CH₄/day (one “super emitter”)
- Kentucky: 54 wells, 53 unplugged, 1 plugged (not leaking), average emission rate similar in magnitude to OK for the unplugged wells (PRELIMINARY)
- Future campaigns
 - KY, NY, TX
 - Gas vs. oil, other distinctions

Providing recommendations to state agencies for well finding, risk characterization, and optimization of mitigation strategies

Results: Oklahoma Field Campaign

Cherokee Platform – Near Tulsa

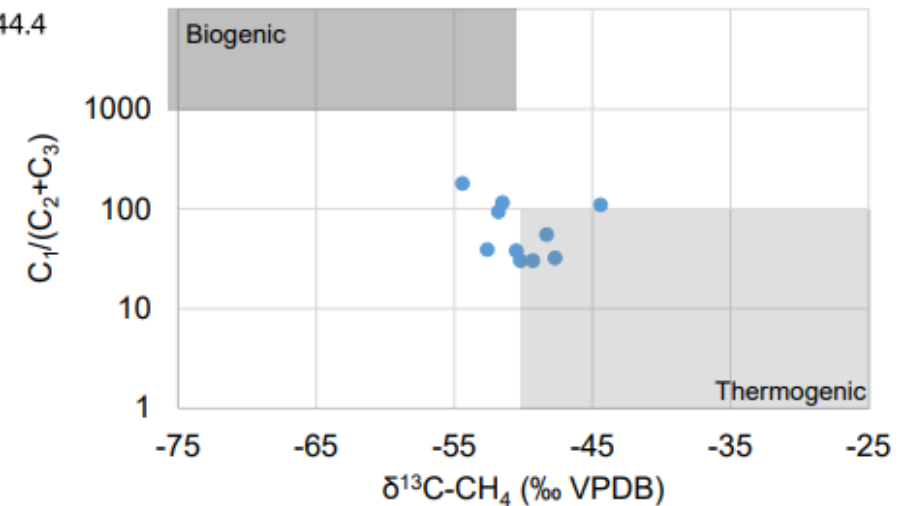
STUDY WELL COUNTS



Gas Composition Analysis

Light Alkanes (C1-C5) by Gas Chromatography, Stable Carbon Isotopic Signature

Analyte/well	1	2	3	4	5	6	7	8	9	10	Mean $\pm$ SD	Min	Max
Methane	98.73	99.42	96.76	96.28	95.06	97.62	97.25	95.30	95.85	98.55	97.08 $\pm$ 1.50	95.06	99.42
Ethane	0.90	0.54	0.51	0.42	0.63	0.55	0.64	0.89	1.24	0.50	0.68 $\pm$ 0.25	0.42	1.24
Propane	<i>n.d.</i>	0.02	2.03	2.05	2.51	0.49	1.13	2.08	1.93	0.36	1.26 $\pm$ 0.97	<i>n.d.</i>	2.51
<i>i</i> -Butane	<i>n.d.</i>	<i>n.d.</i>	0.20	0.35	0.42	0.24	0.25	0.45	0.34	0.18	0.24 $\pm$ 0.16	<i>n.d.</i>	0.45
<i>n</i> -Butane	0.37	0.02	0.26	0.72	0.88	0.65	0.52	0.94	0.50	0.31	0.52 $\pm$ 0.29	0.02	0.94
<i>i</i> -Pentane	<i>n.d.</i>	<i>n.d.</i>	0.11	0.15	0.28	0.22	0.15	0.23	0.13	0.11	0.14 $\pm$ 0.09	<i>n.d.</i>	0.28
<i>n</i> -Pentane	<i>n.d.</i>	<i>n.d.</i>	0.06	0.03	0.21	0.24	0.07	0.13	0.01	0.01	0.08 $\pm$ 0.09	<i>n.d.</i>	0.24
$\delta^{13}\text{C-CH}_4$ (‰)	-44.4	-54.4	-50.5	-52.6	-50.2	-51.8	-48.3	-47.7	-49.3	-51.5	-50.1 $\pm$ 2.8	-54.4	-44.4



Conclusions

Key Findings To Date

- Current estimate of methane emissions from abandoned wells is 3% of contribution from energy sector
 - Large uncertainties remain
- Determining number of wells is difficult due to incomplete records
 - Aerial magnetic surveys a useful technique
- Emissions from wells vary widely
 - Plugged vs. Unplugged
 - Regional differences
 - Need more data to determine other factors that influence emissions
- Leaking gas is >95% methane



[Citizen Science:
Orphan Wells Location
Survey | netl.doe.gov](#)

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