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Reducing methane emissions from documented abandoned and orphaned oil and gas wells in Canada and in the United States

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Abstract : Millions of oil and gas wells are abandoned and orphaned around the world. Due to funding shortfalls, many abandoned and orphaned wells remain unplugged and are negatively impacting the environment and contributing to greenhouse gas emissions, such as methane. To reduce emissions and environmental impacts, the wells are required to be plugged but the well sites can be repurposed for wind and solar energy and/or the wells itself can be redeveloped for geothermal energy production. To quantify methane emissions and identify opportunities for repurposing abandoned and orphaned wells and well sites for renewable energy development, we analyze public oil and gas well data from governmental agencies of documented abandoned and orphaned wells in Canada and the United States. We estimate the total number of abandoned and orphaned wells in Canada and the United States to be 3,500,602, of which 4% are orphaned and in need of government funding. We estimate plugging costs for orphaned wells in the United States to exceed federal funding by 33%-80%. For abandoned and orphaned wells, we quantify methane emissions at the national and state/provincial/territorial level and potential emission reductions achieved through plugging. Furthermore, to evaluate mitigation and redevelopment opportunities, we analyze geographic locations of abandoned and orphaned wells with national maps of renewable energy potential (geothermal, wind, and solar) and land cover/land use in Canada and the United States. Mitigating oil and gas wells can help fulfill national energy transition goals and emission reduction targets, while providing an additional funding stream to manage the millions of abandoned and orphaned wells around the world.

Keywords : Methane, oil and gas wells, abandoned wells, orphaned wells, renewable energy

Acknowledgements: We gratefully acknowledge the funding for this research, which was provided by the Environmental Defense Fund (EDF), Environment and Climate Change Canada (ECCC), the McGill Engineering Undergraduate Student Masters Award (MEUSMA), the Canada Graduate Scholarships — Master’s program (CGS M) provided by the National Science and Engineering Research Council of Canada (NSERC), the Master’s Research Scholarship provided by Fonds de Recherche du Québec — Nature et Technologies (FRQNT). We wish to thank state provincial, and territorial oil and gas regulatory agencies, Environment and Climate Change Canada (ECCC), the Interstate Oil and Gas Compact Commission (IOGCC), Adam Peltz, Kate Roberts, Jack Warren, Renee McVay, Sarah Ahmed, Alicia Qiao, Judy Pak, Kendra Bueley, Rebekah Clarke Robinson, Ziming Wang, Paola Prado, Khalil El Hachem, and James Williams for helping with data collection.

1 Introduction

Abandoned and orphaned oil and gas wells are non-producing wells. They can emit methane, a potent greenhouse gas, and other air pollutants, contaminate groundwater and surface water, degrade ecosystems, and impact human health.

To limit these environmental and climate risks, plugging and remediation is needed, but can be expensive, leaving many abandoned and orphaned wells unplugged.

Abandoned/orphaned wells and well sites may be repurposed for solar, wind, or geothermal energy production. Some of the benefits include:

- Reduce costs of renewable energy deployment (reusing infrastructures and land acquisition/leasing)
- Incentivize well plugging and remediation
- Preserve undeveloped lands that would have otherwise been used for renewable energy development

Research to characterize abandoned and orphaned wells is needed to:

- Reduce methane emissions and other environmental impacts
- Prioritize wells for mitigation
- Repurpose wells and well sites to renewable energy production

Data on abandoned and orphaned wells is needed to inform policies and regulations, such as:

- Optimize federal spending and regulations
- Meet national energy transition goals and emission reduction targets

2 Methodology

Here, we focus on “documented” abandoned and orphaned wells, which are recorded by governmental oil and gas agencies. There are likely many more abandoned and orphaned wells that are undocumented (not currently included in government databases).

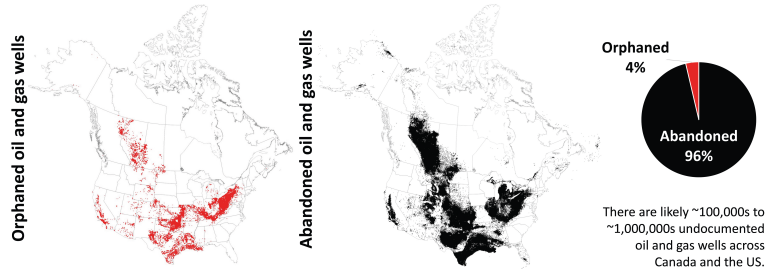
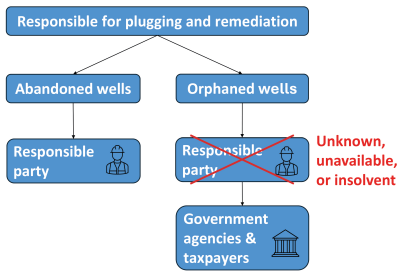
Number, well location, and well depth compiled from public state, provincial, and territorial databases across Canada and the U.S. and quality controlled/checked [1].

Oil and gas regulatory agencies across Canada and the U.S. contacted when information unavailable in public databases.

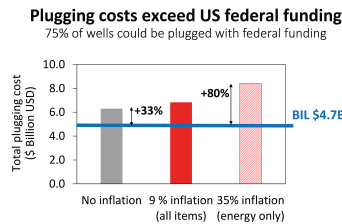
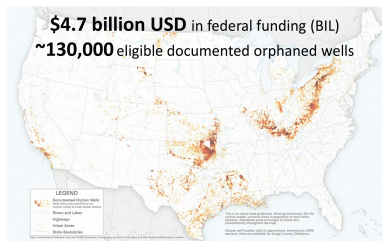
Documented orphaned well definitions and content of state oil and gas well databases vary across states, provinces, and territories making it challenging to compile a continental-scale geospatial dataset. There are many documented abandoned and orphaned wells across Canada and the U.S., but their attributes are scantily documented in governmental databases.

To estimate renewable energy potential, we analyze geographic locations of abandoned and orphaned wells with national maps of land cover/land use and wind, solar and geothermal energy potential.

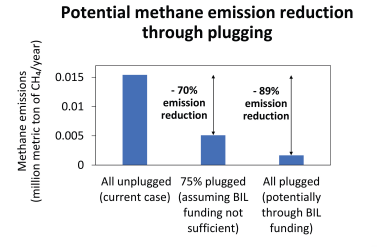
3 3,500,000 documented abandoned and orphaned oil and gas wells in Canada and the US



4 US documented orphaned oil and gas wells



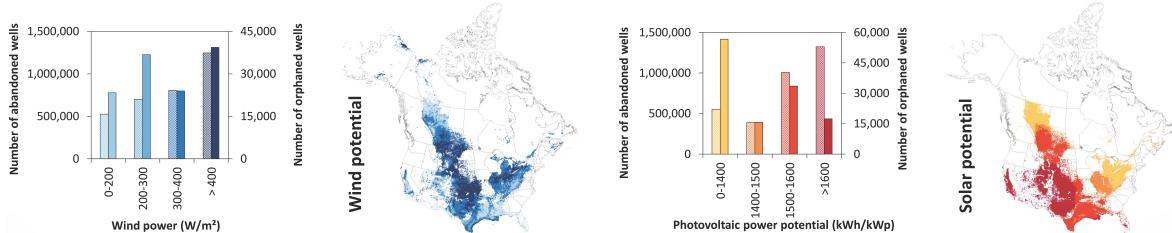
Plugging costs model considers documented orphaned well age and well depth and includes surface clean up and remediation/restoration costs.



Emission factors from Williams et al. (2021) that consider well type (e.g., oil and/or gas).

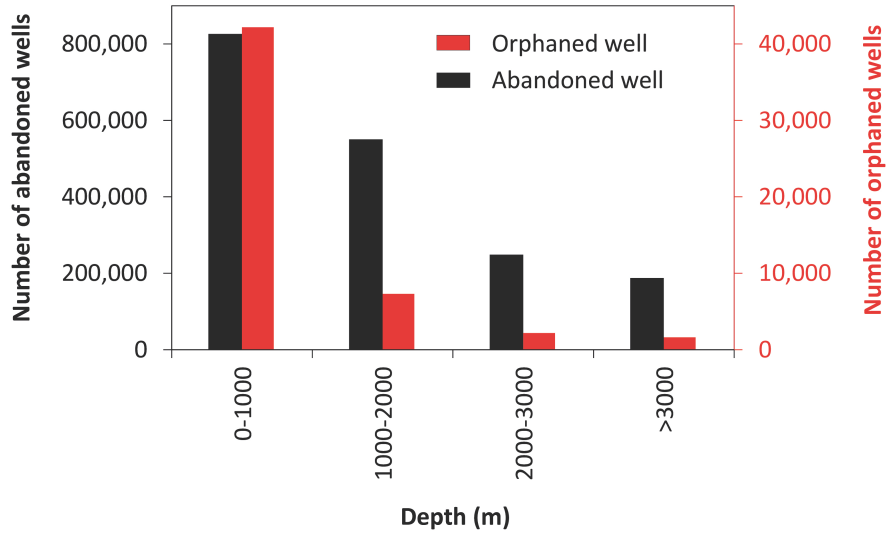
5 Additional funding stream for mitigation and incentive for methane reduction

Converting abandoned and orphaned wells to solar, wind, or geothermal energy production can provide an additional funding stream to repurpose the land, remove and restore existing infrastructures, and plug the wells, all of which provide environmental benefits, stimulate the economy, and incentivize plugging and remediation.



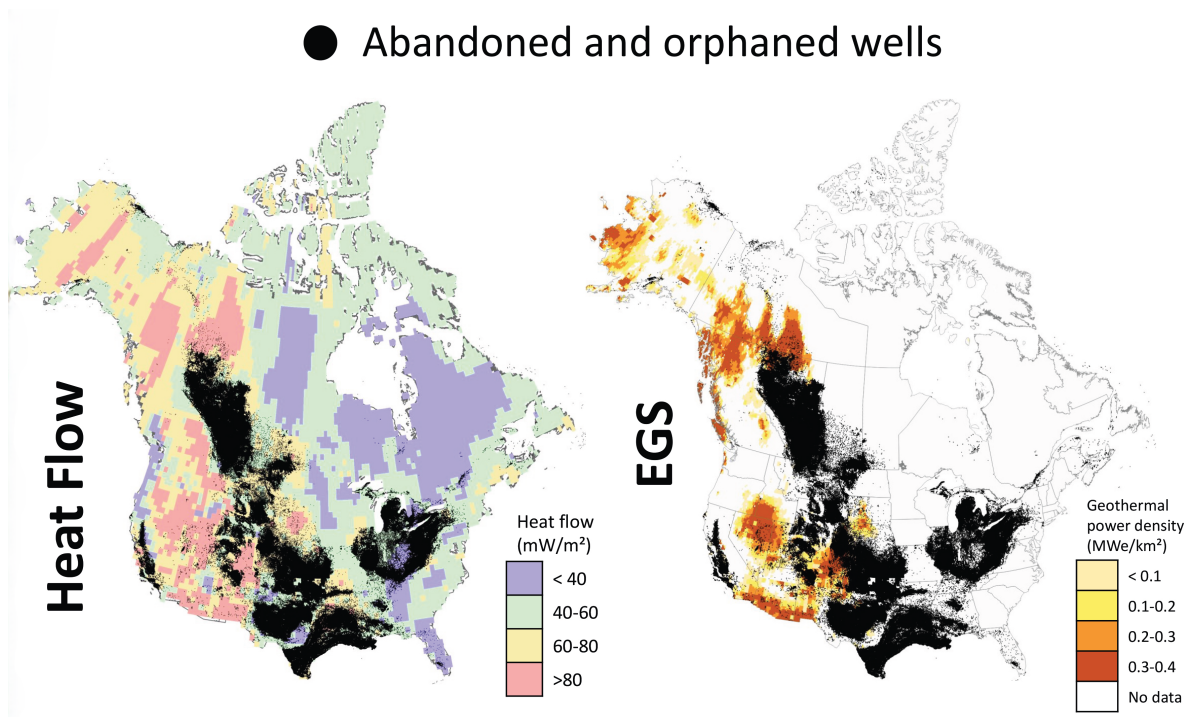
6 Geothermal potential

~90% of orphaned and abandoned wells < 3 km deep



- Data remains unavailable for many wells (e.g., well depth available for 50% of wells)
- Only 10% of abandoned and orphaned wells between 3-10 km deep
 - Enhanced geothermal systems (EGS) – fluid injected into the subsurface to increase rock permeability

● Abandoned and orphaned wells



- Heat flow represents the amount of thermal energy at well site
- Additional analysis is needed to determine if the wells are suitable for heating or electricity production (e.g., outlet water temperature, flow rate, geologic features).

7 Poster

Reducing methane emissions from documented abandoned and orphaned oil and gas wells in Canada and the United States

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SHEAL
Substance Hydrology and Environmental Analysis Laboratory

Introduction

Abandoned and orphaned oil and gas wells are non-producing wells. They can emit methane, a potent greenhouse gas, and other air pollutants, contaminate groundwater and surface water, degrade ecosystems, and impact human health.

To limit these environmental and climate risks, **plugging and remediation** is needed, but can be **expensive**, leaving many abandoned and orphaned wells unplugged.

Abandoned/orphaned wells and well sites may be **repurposed for solar, wind, or geothermal energy production**. Some of the benefits include:

- Reduce energy deployment (renewable infrastructure and land acquisition/leasing)
- Incentivize well plugging and remediation
- Preserve undeveloped lands that would have otherwise been used for renewable energy development

Research to characterize abandoned and orphaned wells is needed to:

- Reduce methane emissions and other environmental impacts
- Prioritize wells for mitigation
- Repurpose wells and well sites to renewable energy production

Data on abandoned and orphaned wells is needed to inform policies and

- Optimize federal spending and regulations
- Meet national energy transition goals and emission reduction targets

Methodology

Here, we focus on “**Measurable**”, **abandoned and orphaned wells**, which are recorded by governmental oil and gas agencies. There are likely many more abandoned and orphaned wells that are **undocumented** (not currently included in government databases).

Number, well location, and well depth compiled from **public state, provincial, and territorial databases** across Canada and the U.S. and **quality controlled/checked***.

Oil and gas available in **public maps**. Canada and the U.S. **connected** when information **unavailable** in public databases.

Documented orphaned well **definitions and content** of state oil and gas agencies **challenging** to compile a consistent scale geospatial dataset. There are many documented abandoned and orphaned wells across Canada and the U.S., but their **attributes are scarcely documented** in government databases.

To estimate renewable energy potential, we analyze geographic locations of abandoned and orphaned wells with national maps of **land cover/land use and wind, solar and geothermal energy potential**.

Orphaned oil and gas wells

Abandoned oil and gas wells

Orphaned 4%, Abandoned 96%. There are likely ~100,000 to ~1,000,000 undocumented oil and gas wells across Canada and the U.S.

US documented orphaned oil and gas wells

\$4.7 billion USD in federal funding (BIL)
~130,000 eligible documented orphaned wells

75% of wells could be plugged with federal funding

Total plugging cost (10 Billion USD): 130,000 wells. 75% could be plugged with federal funding.

Potential methane emission reduction through plugging

80% methane emission reduction (current state)

75% methane emission reduction (with funding cost)

At plugging funding cost through BIL, funding cost sufficient.

Emission factor from Williams et al. (2013) that consider well type (e.g., oil and/or gas)*

At plugging funding cost, funding cost sufficient.

Geothermal potential

~90% of orphaned and abandoned wells < 3 km deep

- Data remains unavailable for many wells (e.g., well depth available for ~50% of wells)
- Only 20% of abandoned and orphaned wells between 3-10 km deep
- Increase in geothermal potential (GEP) and opportunities for subsurface to increase rock permeability

Heat Flow and EGS

Heat flow represents the amount of thermal energy at well site

Additional analysis is needed to determine if the wells are suitable for **heating or electricity production** (e.g., collect water temperature, flow rate, geology, etc.)

Additional funding stream for mitigation and incentive for methane reduction

Converting abandoned and orphaned wells to solar, wind, or geothermal energy production sites, with **additional funding** stream to repurpose the land, **decommission and restore** existing infrastructure, and **plug the wells**, all of which provide **environmental benefits**, stimulate the economy, and increase the plugging rate.

Wind potential

Number of orphaned wells vs. Wind power (W/m²)

Solar potential

Number of orphaned wells vs. Photovoltaic power potential (W/m²/kWp)

Acknowledgements

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*Boutot et al. (2023) Documented orphaned oil and gas wells across the United States. Environmental Science & Technology.
**Kang et al. (2023) Environmental risks and opportunities of orphaned oil and gas wells in the United States. Environmental Research Letters.

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- [2] Mary Kang, Jade Boutot, Renee C. McVay, Katherine A. Roberts, Scott Jasechko, Debra Perrone, Tao Wen, Greg Lackey, Daniel Raimi, Dominic C. Digiulio, Seth B. C. Shonkoff, J. William Carey, Elise G. Elliott, Donna J. Vorhees and Adam S. Peltz (2023) Environmental risks and opportunities of orphaned oil and gas wells in the United States. *Environmental Research Letters*. 18 074012. DOI: 10.1088/1748-9326/acdae7.