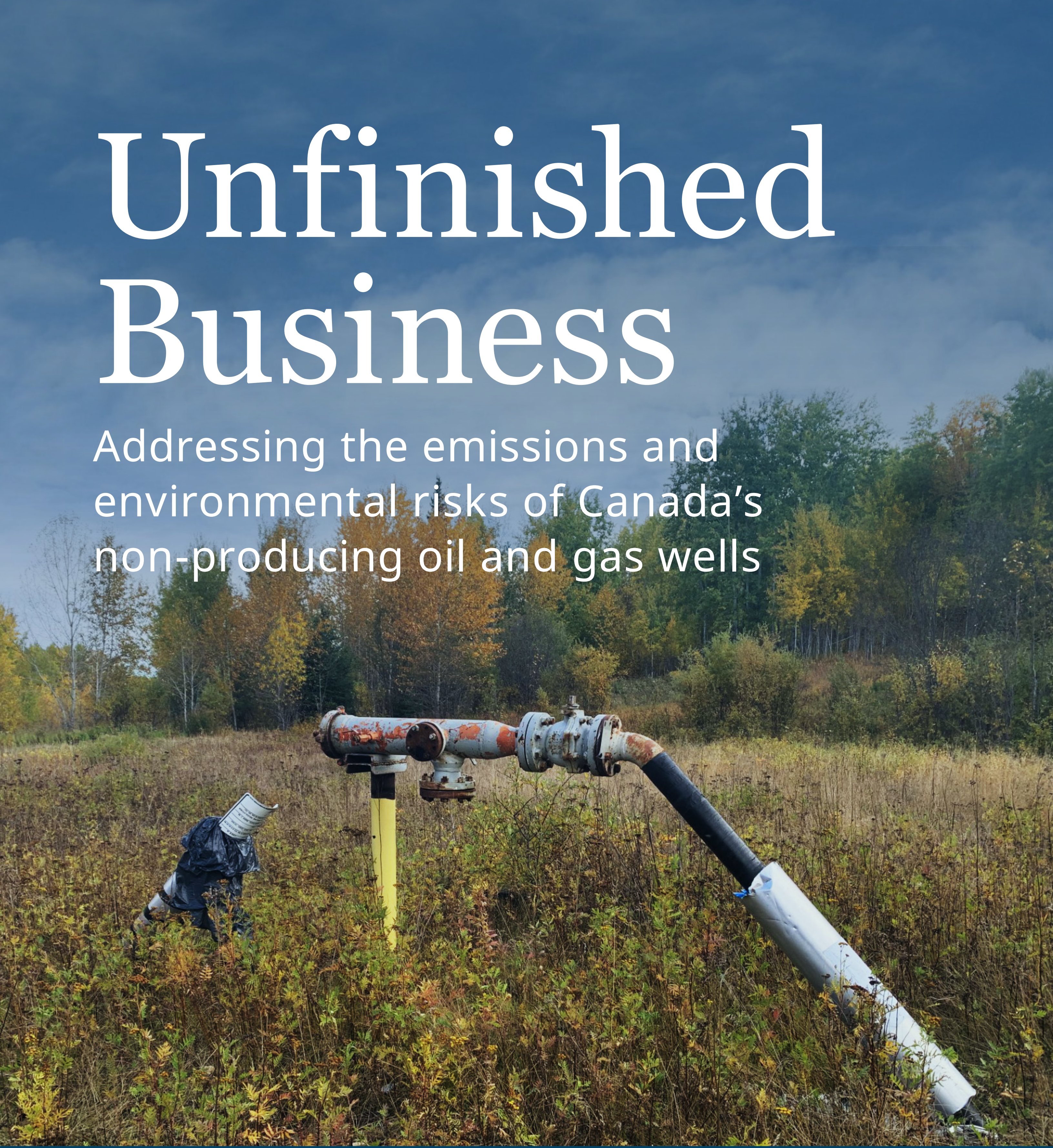
# Unfinished Business

## Addressing the emissions and environmental risks of Canada's non-producing oil and gas wells



July 2025

Amanda Bryant

PEMBINA Institute

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Together, we can lead Canada's transition to clean energy. Your gift directly supports research to advance understanding and action on critical energy and environmental issues. Canadian charitable number 87578 7913 RR 0001; pembina.org/donate

## Acknowledgements

The Pembina Institute recognizes that the work we steward and those we serve span the lands of many Indigenous Peoples. We respectfully acknowledge that our organization is headquartered in the traditional territories of Treaty 7, comprising the Blackfoot Confederacy (Siksika, Piikani and Kainai Nations); the Stoney Nakoda Nations (Goodstoney, Chiniki and Bearspaw First Nations); and the Tsuut'ina Nation. These lands are also home to the Otipemisiwak Métis Government (Districts 5 and 6).

These acknowledgements are part of the start of a journey of several generations. We share them in the spirit of truth, justice and reconciliation, and to contribute to a more equitable and inclusive future for all.

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# Executive summary

There are estimated to be over 520,000 non-producing (inactive, suspended, abandoned and orphaned) oil and gas wells in Canada. While many are located in relatively sparsely populated rural areas, they nevertheless can be found close to homes and buildings, and some also exist in urban population centres. There is broad consensus among government, regulators, industry and the public that wells that have reached their end-of-life should be properly plugged and reclaimed, to return the land to its original state and allow landowners and communities to reclaim the land for other uses. As such, there has been a growing public discussion over several years about appropriate policies to manage the closure of wells and to ensure that polluting industries (oil and gas companies) honour their obligation to shoulder the financial burden of this remediation work. These conversations are especially important as governments consider new policy options to tackle the issue of non-producing wells, such as Alberta's proposed Mature Asset Strategy, which could end up placing the financial burden on taxpayers instead.

However, there has been comparatively less focus on the environmental risks and health hazards associated with these legacy oil and gas assets. These include their potential to leak methane and other pollutants into the atmosphere and into groundwater. Canada's non-producing wells are estimated to have been responsible for 13% of unintended (fugitive) emissions from Canada's oil and gas systems in 2023 (230 kilotonnes of methane). Gaining a greater understanding of these risks is important if Canada's governments and regulators are to design appropriate policy to address what is as much an issue of public and ecological health as it is of land-use planning and private sector asset management.

What is more, as the global energy transition accelerates and Canada's oil and gas industry faces an increasingly competitive global market, it is reasonable to expect that shifting economics and aging infrastructure will cause faster growth in the population of non-producing wells in the years ahead.

Our report identifies key trends on methane emissions from non-producing wells and provides policy recommendations. To do this, we analyzed the two main sources of methane emissions data — industry reports to energy regulators and academic studies — and brought our findings together in this report.

Our analysis revealed the following:

- Tens of thousands of non-producing wells in western Canada are waiting to be plugged, remediated, and reclaimed.

- In Alberta and British Columbia, nearly half of suspended wells (those which in theory could be put back into production at any time) have been suspended for over 10 years.
- Leaks from non-producing wells are typically low but vary across regions and could contribute significantly to Canada's emissions profile on a cumulative basis.
- Leaks that are designated as "serious" can remain unresolved for years or decades.
- Factors such as well type, history, status, construction, and plugging materials could help determine how likely a well is to leak, but official data on these attributes is often incomplete or inaccurate.

Based on these findings, we developed four main policy recommendations for non-producing wells:

1. **Disincentivize long-term well inactivity and improve leak databases** through regulated closure timelines and quotas, strengthened testing and repair requirements, improved data collection and management, and enhanced enforcement.
2. **Improve measurement, monitoring, reporting, and verification** by funding measurement and monitoring initiatives, strengthening reporting standards, and prioritizing data quality checks and data transparency.
3. **Tailor methane mitigation to the regional context** by gathering region-specific data on well attributes and emissions, analyzing trends and identifying known problem wells, and using this information to design region-specific mitigation strategies.
4. **Characterize and mitigate risks of methane leaks** by collecting regional data on risk factors, using a range of tools and strategies to identify problem wells, and prioritizing leak monitoring at potentially high-risk wells.

# 1. Introduction

Oil and gas wells, both those that are currently in operation (producing) and those that are not (non-producing), can emit methane gas into the atmosphere and leak it into the subsurface. In this report, we examine industry-reported data and academic studies to better understand the scope and causes of this problem among non-producing wells and to develop evidence-based policy recommendations. We focus specifically on inactive, suspended, abandoned, and orphaned wells.[1]

Terminology is challenging because different jurisdictions use different terms to describe well statuses and often define the same terms differently. This creates substantial confusion. The table below sets out how we've defined well statuses in this report.

Table 1. Defined well statuses

| Well status | Definition |
|---|---|
| Active | Currently producing or supporting production, or in the process of being drilled or completed. |
| Non-producing | |
| Shut-in | Valves at the wellhead are temporarily closed. |
| Inactive/idle | Has not produced in a specified number of months but is not yet permanently plugged with cement and abandoned. |
| Suspended | Well licence has been suspended, and well has likely been locked and may have been temporarily plugged depending on local requirements. |
| Abandoned/ decommissioned | Permanently out of service and may be plugged or unplugged depending on time of abandonment (present-day abandonment requires plugging). |
| Orphaned | Has no responsible owner, typically due to company insolvency. |
| Reclaimed | Permanently plugged, cut and buried, and land restored to a state comparable to the state it was in before development. |

[1] We do not address reclaimed wells at any length. It is worth noting that the Alberta Energy Regulator has automated the process of issuing reclamation certificates. Some reports suggest that many sites that have "reclaimed" status are not properly reclaimed, as noted by Sharon Riley in "Many of Alberta's 'Reclaimed' Wells Aren't Actually Reclaimed: Government Presentation," *The Narwhal*, December 6, 2018. https://thenarwhal.ca/many-of-albertas-reclaimed-wells-arent-actually-reclaimed-government-presentation/. Further research into the condition of reclaimed wells is therefore advisable.

Methane is a potent greenhouse gas with over 80 times the warming power of carbon dioxide over a 20-year timespan. Preventing methane from leaking into the atmosphere is therefore a high-impact opportunity for corporate and government leadership on climate and low-emissions energy production. Mitigating methane emissions has many co-benefits, including ensuring access to international markets for Canadian energy products,[2] generating more good jobs in the technology and service industry,[3] and improving the geologic storage of captured carbon dioxide by mitigating leak pathways from the well infrastructure.[4]

Addressing leaks also reduces environmental harms and health and safety risks. For instance, a recent study showed that there are orphan wells in aquifers that supply 94% of U.S. groundwater use,[5] and subsurface methane leaks can contaminate groundwater.[6] Methane leaks from abandoned wells in urban areas, such as areas of past oil and gas production in Ontario, have also led to explosions.[7]

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[2] Amanda Bryant, "Action on methane makes sense now more than ever," *Pembina Institute*, February 12, 2025. https://www.pembina.org/blog/action-methane-makes-sense-now-more-ever

Amanda Bryant, "Newly adopted European Union methane regulations are a game-changer," *Pembina Institute,* June 4, 2024. https://www.pembina.org/blog/newly-adopted-european-union-methane-regulations-are-game-changer

[3] Marcy Lowe, *Canada's Methane Opportunity: Innovation, Exports, Jobs* (Datu Research, 2025). https://www.pembina.org/pub/canadas-methane-opportunity-innovation-exports-jobs

[4] Alsubaih, Ahmed, Kamy Sepehrnoori, and Mojdeh Delshad, "Environmental Impacts of Orphaned and Abandoned Wells: Methane Emissions, and Implications for Carbon Storage," *Applied Sciences* 14, no. 24 (2024). https://doi.org/10.3390/app142411518

Kang, Mary, Jade Boutot, Renee McVay, et al., "Environmental Risks and Opportunities of Orphaned Oil and Gas Wells in the United States," *Environmental Research Letters* 18, no. 7 (2023), 8. https://doi.org/10.1088/1748-9326/acdae7

[5] Woda, Joshua, Karl Haase, Nicholas Gianoutsos, et al., "A Geospatial Analysis of Water-Quality Threats from Orphan Wells in Principal and Secondary Aquifers of the United States," *Science of The Total Environment* 976 (2025). https://doi.org/10.1016/j.scitotenv.2025.179246

[6] McMahon, Peter, Judith Thomas, John Crawford, et al., "Methane in Groundwater from a Leaking Gas Well, Piceance Basin, Colorado, USA," *Science of The Total Environment* 634 (2018). https://doi.org/10.1016/j.scitotenv.2018.03.371

Soares, Julia, Chitra Chopra, Cole Van De Ven, et al., "Towards Quantifying Subsurface Methane Emissions from Energy Wells with Integrity Failure," *Atmospheric Pollution Research* 12, no. 12 (2021). https://doi.org/10.1016/j.apr.2021.101223

[7] El Hachem, Khalil, Christian von Sperber, Charlotte Allard, et al., "Characterizing Multifaceted Environmental Risks of Oil and Gas Well Leakage through Soil and Well Methane and Hydrogen Sulfide Emissions," *Environmental Research* 264 (2025), 9. https://doi.org/10.1016/j.envres.2024.120254

Kang et al., "Environmental Risks and Opportunities," 6.

Schout, Gilian, Jasper Griffioen, Majid Hassanizadeh, et al., "Occurrence and Fate of Methane Leakage from Cut and Buried Abandoned Gas Wells in the Netherlands," *Science of The Total Environment* 659 (2019). https://doi.org/10.1016/j.scitotenv.2018.12.339

Other health risks include exposures to co-pollutants such as volatile organic compounds and hydrogen sulphide (also known as “sour gas”).[8] A study of abandoned wells in Pennsylvania detected cancer-causing benzene at roughly 70% of the wells sampled.[9] Hydrogen sulphide is fatal at concentrations above 500 parts per million, and lower concentrations can cause loss of consciousness and respiratory distress.[10] Non-producing oil and gas wells that emit high concentrations of hydrogen sulphide have been identified in both the U.S.[11] and Canada.[12]

There are estimated to be over 520,000 non-producing wells in Canada.[13] This number includes both documented wells (i.e., wells that are listed in official records) and undocumented ones. Alberta accounts for the vast majority of these wells, with an estimated 358,175 non-producing wells. There are also an estimated 80,124 in Saskatchewan, 53,169 in Ontario, and 21,542 in British Columbia (Figure 1).[14]

[8] Kang et al., “Environmental Risks and Opportunities,” 6.

[9] DiGiulio, Dominic, Robert Rossi, Eric Lebel, et al., “Chemical Characterization of Natural Gas Leaking from Abandoned Oil and Gas Wells in Western Pennsylvania,” *ACS Omega* 8, no. 22 (2023). https://doi.org/10.1021/acsomega.3c00676

El Hachem et al., “Multifaceted Environmental Risks.”

[10] Galaszkiewicz, Aden, Keith Delaney, and Colby Steelman, “Identifying Sulphurous Water Discharge from Legacy Oil and Gas Wells Using Spectral Band Analysis of Aerial and Satellite Imagery,” *Geomatica* 76, no. 2 (2024), 1. https://doi.org/10.1016/j.geomat.2024.100024

[11] Townsend-Small, Amy, and Jacob Hoschouer, “Direct Measurements from Shut-in and Other Abandoned Wells in the Permian Basin of Texas Indicate Some Wells Are a Major Source of Methane Emissions and Produced Water,” *Environmental Research Letters* 16, no. 5 (2021). https://doi.org/10.1088/1748-9326/abf06f

[12] Galaszkiewicz et al., “Identifying Sulphurous Water Discharge,” 1–2.

El Hachem, Khalil, and Mary Kang, “Methane and Hydrogen Sulfide Emissions from Abandoned, Active, and Marginally Producing Oil and Gas Wells in Ontario, Canada,” *Science of The Total Environment* 823 (2022). https://doi.org/10.1016/j.scitotenv.2022.153491

El Hachem et al., “Multifaceted Environmental Risks.”

[13] Klotz, Louise A., Liam Woolley, Bianca Lamarche, et al., “Sevenfold Underestimation of Methane Emissions from Non-Producing Oil and Gas Wells in Canada,” *Environmental Science & Technology* 59, no. 18 (2025), 9010. https://doi.org/10.1021/acs.est.4c05602

[14] Klotz, Louise, Liam Woolley, Bianca Lamarche, et al., “Supporting Information: Sevenfold underestimation of methane emissions from non-producing oil and gas wells in Canada,” Table S4. http://www.doi.org/10.1021/acs.est.4c05602?goto=supporting-info

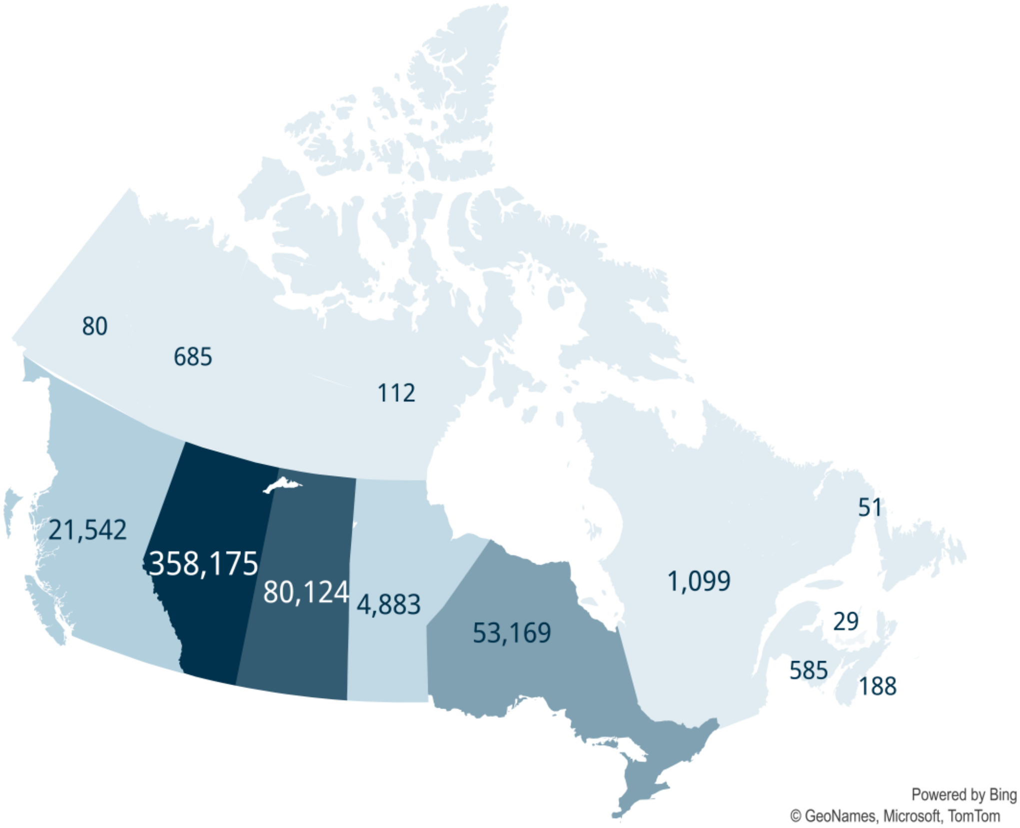


Figure 1. Estimated numbers of non-producing wells (documented and undocumented) across Canada

Data source: Klotz et al.[15]

As such, there is every reason to prevent methane leaks from oil and gas infrastructure, including non-producing wells. Yet regulations requiring methane emissions to be monitored and mitigated apply primarily to active wells. A company's responsibility for methane emissions at its wells ends at the abandonment stage or through insolvency. This means that emissions from non-producing oil and gas wells are poorly understood compared to emissions from active sites and sometimes go undetected. The magnitude of emissions from these wells is therefore highly uncertain. However, evidence suggests that the collective contribution of these wells to total emissions is significant. In 2023, Canada's non-producing wells emitted an estimated 230 kilotonnes of methane, or 13% of total fugitive (unintended) emissions from Canada's oil and gas systems.[16]

As global demand for oil and gas declines in the coming decades, more wells are likely to reach their end-of-life. As a result, the proportion of non-producing wells in relation to producing wells is likely to grow. In addition, the transition away from fossil fuels is likely to lead to more

[15] Klotz et al., "Supporting Information," Table S4.

[16] Klotz et al., "Sevenfold Underestimation," 9008.

company insolvencies and more orphaned wells. But even with responsible owners still in place, current regulations allow wells to be inactive or suspended indefinitely, meaning emissions can remain unresolved for decades. Concerningly, proposals like the Mature Asset Strategy (currently being developed by the Government of Alberta)[17] may shift the financial burden of this aging infrastructure from private companies to Albertans through the creation of provincial entities that would acquire and manage aging oil and gas wells. Sound policy alternatives are therefore needed to manage the growing health, environmental and financial risks from these wells while upholding the polluter pays principle.

In this report, we unearth key trends regarding methane emissions from non-producing wells and provide four main policy recommendations. Our analysis involved reviewing the two main sources of methane emissions data — industry reports to energy regulators and academic studies. We arranged our findings and policy recommendations according to the data source.

[17] Government of Alberta, *Mature Asset Strategy: What we heard and recommendations report* (2025). https://open.alberta.ca/dataset/c1e0fc7b-ee55-4797-b640-5a2f4657d895/resource/0fcdf8c6-86a1-4e41-97f6-65e175982423/download/em-mature-asset-strategy-2025-04.pdf

# 2. Industry-reported data – Analysis and recommendations

## 2.1 Aging inactive wells

According to official data, about half of all wells in western Canada are abandoned or suspended (Figure 2).

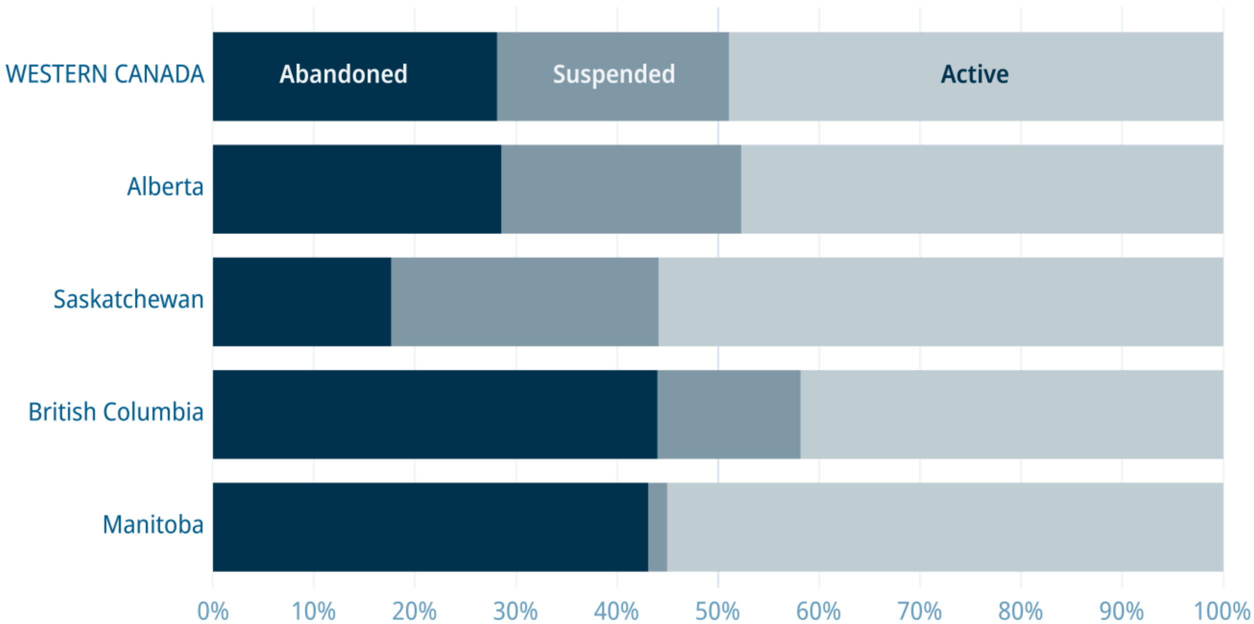


Figure 2. Share of wells by licence status across Canada's oil and gas producing provinces

Data sources: Alberta Energy Regulator, British Columbia Energy Regulator, Saskatchewan Energy and Resources, Government of Manitoba[18]

In Alberta and British Columbia, 47% of suspended wells (33,000) have been suspended for over 10 years (Figure 3). Wells that have been suspended for that long are unlikely to be put back into production and are waiting for permanent plugging and reclamation. By sitting in a non-active state with limited surveillance, they generate no economic benefit, accrue financial liability, and pose serious environmental risks from surface and subsurface methane leaks.

[18] AER, "Inactive Well Licence List." https://www1.aer.ca/productcatalogue/360.html

BCER, "Well Index [BCOGC-2555]." https://www.bc-er.ca/data-reports/data-centre/?category=2772

Saskatchewan Energy and Resources, "LLR Well List." https://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/oil-and-gas/liability-management/licensee-liability-rating-program/licensee-liability-rating-program-reports

Government of Manitoba, "Unique Well Identifier Key List." https://www.gov.mb.ca/iem/petroleum/reports/index.html

Operators may leave wells suspended for long periods of time to delay or avoid the costs of repair, which vary widely and can be substantial.[19] A 2019 study estimated that the cost of normal plugging and abandonment in B.C. was $50,000 per well, while another study revealed that plugging wells with significant leakage issues can be quite expensive, with one well costing over $1.9 million to abandon in 2012.[20] The total number of suspended wells is also growing in regions such as Alberta (Figure 3),[21] which means the economic liabilities associated with proper plugging, abandonment, and remediation are likewise growing. As the energy transition accelerates and more companies become insolvent, the risk that these liabilities will be transferred to taxpayers in Alberta will grow.

Figure 3 shows the number of new well suspensions in Alberta and B.C. each year. The count includes wells that have a current "suspended" licence status and excludes wells that were suspended and then moved to abandoned or producing.

[19] Abboud, J., T. Watson, and M. Ryan, "Fugitive Methane Gas Migration around Alberta's Petroleum Wells," *Greenhouse Gases: Science and Technology* 11, no. 1 (2021), 46. https://doi.org/10.1002/ghg.2029

Seymour, Scott, Donglai Xie, and Mary Kang, "Highly Uncertain Methane Leakage from Oil and Gas Wells in Canada Despite Measurement and Reporting," *Energy & Fuels*, 14 (2024), 13085. https://doi.org/10.1021/acs.energyfuels.4c00908

[20] Trudel, E., M. Bizhani, M. Zare, and I. Frigaard, "Plug and Abandonment Practices and Trends: A British Columbia Perspective," *Journal of Petroleum Science and Engineering* 183 (2019), 5. https://doi.org/10.1016/j.petrol.2019.106417

[21] Abboud et al., "Fugitive Methane Gas Migration," 46.

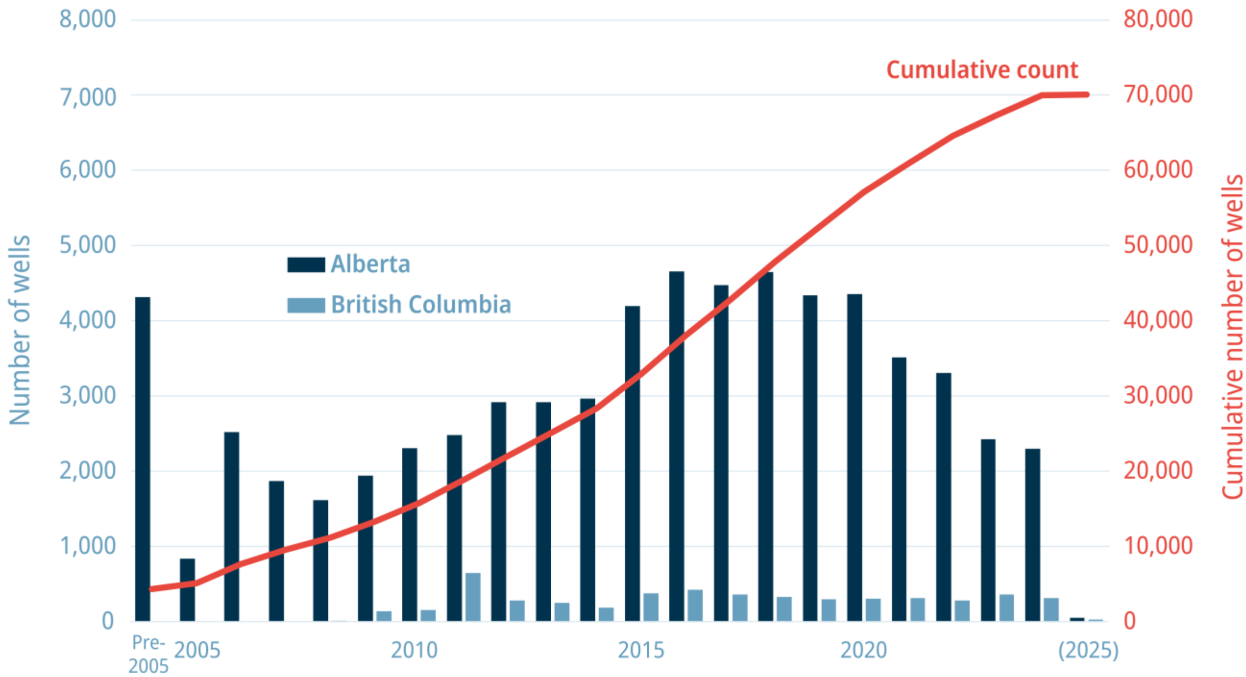


Figure 3. Annual and cumulative counts of well suspensions in Alberta and B.C.

Data sources: Alberta Energy Regulator, British Columbia Energy Regulator[22]

## 2.1.1 Non-producing well policies

All of Canada's oil and gas producing jurisdictions currently allow wells to be indefinitely inactive.[23] But it wasn't always that way. In 1997, Alberta initiated the Long Term Inactive Well Program, which required companies to abandon or reactivate wells after five years of inactivity to avoid paying a security deposit.[24] The program was eventually eliminated. Below we provide more recent policies from both Canada and the U.S. to manage and mitigate inactive wells, focusing on (1) timelines and mandated licensee expenditures and (2) public spending to cover industry obligations.

[22] Alberta Energy Regulator (AER), "Inactive Well Licence List." https://www1.aer.ca/productcatalogue/360.htmlBritish Columbia Energy Regulator (BCER), "Suspended Wells." https://iris.bcogc.ca/reports/rwservlet?prd_ogcr502w

[23] AER, *Directive 013: Suspension Requirements for Wells.* https://static.aer.ca/prd/documents/directives/Directive013.pdf

BCER, *Drilling and Production Regulation*, B.C. Reg. 282/2010, 25. https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/282_2010

[24] Abboud et al., "Fugitive Gas Migration," 41.

### Timelines and mandated licensee expenditures

- Alberta has put in place a well closure spend requirement that sets out the minimum amount licensees must spend on closure work each year. For 2025, the amount is $750 million.[25] Analysis suggests that the amount needs to be significantly higher to adequately address the province's inactive well problem.[26]
- Manitoba issues suspension approvals that are valid for no more than three years, meaning operators must justify continued suspension every three years.[27]
- U.S. federal regulations require wells on federal lands that are suspended for four years or more to be returned to production or abandoned or to have a plan for future use.[28]
- Some U.S. states, such as North Dakota and Texas, require inactive wells not returned to production to be plugged and abandoned within one year of becoming inactive.[29]
- California requires oil companies to eliminate between 5% and 15% of their idle wells each year between 2025 and 2027, with increasing elimination requirements in subsequent years.[30]
- California also has a tiered fee system for idle wells. Fees range between US$1000/well/year for wells that have been idle under three years, and starting in 2029, US$60,000/well/year for wells idle over 25 years.[31]

### Public spending to cover industry obligations

Some governments have dedicated public funds to plugging and remediating inactive and orphan wells.

[25] AER, "Alberta Energy Regulator announces $50 million increase to Closure Spend Requirement in 2025," media release, July 25, 2024. https://www.aer.ca/about-aer/media-centre/news-releases/news-release-2024-07-25

[26] Drew Yewchuk, "The Alberta Energy Regulator's Planned Timelines for Orphan, Inactive, and Decommissioned Oil and Gas Infrastructure," *ABLawg*, August 16, 2024. https://ablawg.ca/2024/08/16/the-alberta-energy-regulators-planned-timelines-for-orphan-inactive-and-decommissioned-oil-and-gas-infrastructure/

[27] Manitoba Agriculture and Resource Development, "Well Suspension Guidelines." https://www.manitoba.ca/iem/petroleum/infonotes/21-04.pdf

[28] 43 CFR § 3162.3-4, (3). https://www.law.cornell.edu/cfr/text/43/3162.3-4

[29] 16 Tex. Admin. Code § 3.14.b.2. https://www.law.cornell.edu/regulations/texas/16-Tex-Admin-Code-SS-3-14North Dakota Administrative Code (NDAC), Section 43-02-03-55. https://ndlegis.gov/files/rule-changes/changes/ic100923changes.pdf

[30] California Assembly Bill 1866: Oil and gas: idle wells (2024).https://calmatters.digitaldemocracy.org/bills/ca_202320240ab1866?slug=CA_202320240AB1866

[31] California Department of Conservation, Geologic Energy Management Division, "Notice to Operators: Requirements for Idle Wells Effective January 1, 2025," November 18, 2024. https://www.conservation.ca.gov/calgem/Documents/2024-13%20NTO%20-%20Idle%20Well%20Requirements.pdf

- The U.S. Federal Orphaned Well Program allocated $US 4.7 billion for plugging, remediating, and reclaiming orphan oil and gas wells.[32] (However, this funding was subsequently frozen by the Trump administration.)[33]
- In 2020, Canada's federal government committed $1.7 billion to Alberta, B.C., and Saskatchewan for cleaning up orphan and inactive wells.[34] Alberta returned over $137 million in unspent funds due to time constraints and a slow roll-out of the application process.[35]
- In 2024, Ontario gave municipalities $2.5 million to help them manage hazards from inactive oil and gas wells.[36]
- From 2017 to 2020, Alberta provided the Orphan Well Association[37] with a $335 million interest-free loan to accelerate orphan well reclamation.[38]
- Between 2010 and 2024, Alberta paid over $128 million to cover rent that delinquent oil and gas companies owed to landowners.[39] Less than 1% of that money has been recouped from the companies.[40] Rent can be owed for wells of any status, but since inactive and suspended wells accrue financial liabilities while not generating revenue, they contribute to the inability of companies to pay rent.

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[32] U.S. Department of the Interior, "Interior Department Releases Final Guidance for States to Access up to $1.5 Billion from President Biden's Investing in America Agenda to Address Legacy Pollution," media release, January 15, 2025. https://www.doi.gov/pressreleases/interior-department-releases-final-guidance-states-access-15-billion-president-bidens

[33] Nick Bowlin, "Trump Halts Historic Orphaned Well-Plugging Program," *High Country News*, March 27, 2025. https://www.hcn.org/articles/trump-halts-historic-orphaned-well-plugging-program/

[34] Indian Oil and Gas Canada, "COVID-19 Update #4: Follow-up on $1.72 Billion for Orphan and Inactive Wells in Alberta, British Columbia, and Saskatchewan," May 1, 2020. https://www.pgic-iogc.gc.ca/eng/1588343274882/1588355750048

[35] Kyle Bakx, "'A Lost Opportunity': Alberta gives back $137M to Ottawa in unspent funds to clean up inactive wells," *CBC News*, September 17, 2024. https://www.cbc.ca/news/canada/calgary/alberta-orphan-wells-inactive-decommision-1.7324701

[36] Government of Ontario, "Ontario Keeping Communities Safe from Risks Associated with Old Oil and Gas Wells" media release, June 12, 2024. https://news.ontario.ca/en/release/1004701/ontario-keeping-communities-safe-from-risks-associated-with-old-oil-and-gas-wells

[37] Alberta's Orphan Well Association is a non-profit organization responsible for closing oil and gas sites that do not have responsible owners. It is primarily funded by industry levies but also benefits from government loans. Some experts argue that the association is badly underfunded. [Drew Yewchuk, *Why the Polluter Has Not Paid: Alberta's under-funded orphan program* (C4RE, 2025). https://responsibleenergyab.ca/wp-content/uploads/c4re-report-why-the-polluter-has-not-paid-albertas-under-funded-orphan-program-may-2025.pdf]

[38] Government of Alberta, "Oil and Gas Liabilities Management." https://www.alberta.ca/oil-and-gas-liabilities-management

[39] Sharon Riley, "Alberta Spent $30M on Unpaid Land Rent for Delinquent Oil and Gas Companies in 2024," *The Narwhal,* July 28, 2025. https://thenarwhal.ca/alberta-oil-and-gas-unpaid-rent-2024/

[40] "Alberta Spent $30M on Unpaid Land Rent."

- Alberta's proposed Mature Asset Strategy contemplates the creation of Crown corporations to assume responsibility for mature oil and gas wells,[41] produce their last drops, and use the resulting funds to pay for clean-up.[42] Private companies have followed a similar model in the past — purchasing wells with declining production. However, the often low profitability of mature and marginally producing wells, combined with potentially high clean-up costs, has meant that, in practice, companies have folded before getting to the point of remediating their wells.[43] In the case of the proposed Mature Asset Strategy, if the Crown corporations were similarly unable to generate sufficient revenue to cover clean-up costs, the public could end up shouldering the financial burden.

Governments taking steps to address the environmental impacts of non-producing wells is a good thing. However, it is important to uphold the polluter pays principle — those who pollute should pay to clean it up, rather than this cost being shifted to the public. This requires stringent policies to prevent wells from becoming orphaned in the first place. Recently introduced rules for renewable energy projects in Alberta require projects to post security for 30–60% of estimated reclamation costs;[44] the oil and gas industry does not have similarly strict standards.

## 2.2 Multiple emissions pathways

Although non-producing wells are no longer actively producing oil and gas, they can still emit methane. The gas can escape from a non-producing well in three ways: through the wellhead, through surface casing vent flow (SCVF), and through gas migration (GM). The latter two are shown in Figure 4.

SCVF occurs when gas or liquids flow into the gap between a well's inner casing layers and out of a vented pipe at the surface. GM occurs when gas moves out of the wellbore through cracks in the casing or cement and into the subsurface and surface soil.

These issues have many causes, including cracked or corroded casing and cement, failed downhole components, subpar construction standards and materials, earthquakes, and increased pressure due to fluid injections. SCVF is a greater source of methane emissions to the

[41] Alberta defines mature assets as those "at a stage where production rates are declining, making it marginal or uneconomic to continue operation at present or at some point in the near future." [*Mature Asset Strategy*, 17.]

[42] Government of Alberta, *Mature Asset Strategy*, 38.

[43] Kyle Bakx, "Number of orphan wells in Alberta will soon double as controversial oilpatch bankruptcy settled," *CBC News*, October 1, 2024. https://www.cbc.ca/news/canada/calgary/bakx-owa-seqouia-pwc-alberta-orphan-wells-1.7336635

[44] Government of Alberta, *Code of Practice for Solar and Wind Renewable Energy Projects* (2025), s.5(4)–(5). https://kings-printer.alberta.ca/1266.cfm?page=Renewables.cfm&leg_type=Codes&isbncln=9780779853038

atmosphere, while GM is a greater source of groundwater contamination. Because GM is more challenging to measure from the surface, it is less frequently tested and reported than SCVF.

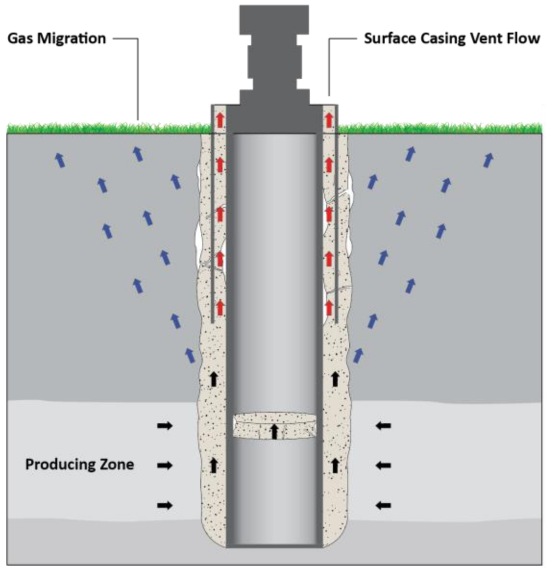


Figure 4. Surface casing vent flow and gas migration from a well

Source: Tiago Morais[45]

## Testing requirements

Requirements for leak monitoring and testing at non-producing wells vary across jurisdictions, but there are some commonalities.

- Leak detection and repair (LDAR) surveys that monitor for above-surface leaks from equipment and components are generally only required at active sites, but several jurisdictions require monitoring at inactive sites, particularly in populated areas.
- SCVF testing is generally required or recommended prior to suspension and abandonment. [46]

45 Tiago Morais, CC BY-SA 4.0 via Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Surface_Casing_Vent_Flow_vs_Gas_Migration.png

46 For instance, in Alberta, SCVF testing is only recommended prior to well suspension.

AER, *Directive 013*, s. 2.3.2.

AER, *Directive 020: Well Abandonment*, s. 7.242. https://static.aer.ca/prd/documents/directives/Directive020.pdf

AER, *Directive 087: Well Integrity Management*, s. 3.2.1.20. https://static.aer.ca/prd/documents/directives/directive-087.pdf

BCER, *Drilling and Production Regulation*, s. 41.2(d)–(e).

Government of Saskatchewan, *Directive PNG015: Well Abandonment Requirements*, s. 9.1. https://pubsaskdev.blob.core.windows.net/pubsask-prod/85291/Directive%252BPNG015-Well%252BAbandonment%252BRequirements%252Bv.2.pdf

- GM testing is required in certain areas or situations in which GM is more likely.[47] It is not mandatory, only recommended, prior to abandonment.[48]
- Regulators distinguish between "serious" and "non-serious" leaks. Serious can mean a high gas flow rate, liquid leakage, presence of hydrogen sulphide, risks to groundwater, or other immediate hazards to environment or health.[49]
- Serious leaks are to be addressed within a reasonable timeframe. For instance, in Alberta, operators have 90 days to resolve serious SCVF and GM.[50]

## 2.3 Poor data quality

We initially sought to analyze and derive insights from industry-reported SCVF and GM testing data for this report. However, we found that the data quality was insufficient for us to confidently derive conclusions about average leak rates and durations without making numerous assumptions and undertaking additional modelling.[51]

Alberta publishes industry SCVF and GM data in a single report.[52] B.C. maintains both a SCVF database[53] and a GM database.[54] However, the GM database does not contain emissions rates; it only indicates the severity of the event. Saskatchewan and Manitoba do not publicly release SCVF and GM reports.

The data, such as it is, appears to show that abandoned wells have a *higher* average reported leak rate than suspended wells (Table 23 in Appendix A). As we will see in section 3, measurement studies show that plugged wells leak less on average than unplugged wells, and abandoned wells are generally supposed to be plugged. So, we would expect abandoned wells to have a lower average reported leak rate than suspended wells.

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47 AER, *Directive 020*, s. 7.1.243.

BCER, *Oil and Gas Operations Manual*, s. 9.7.6. https://www.bc-er.ca/files/operations-documentation/Oil-and-Gas-Operations-Manual/ogaom-chapter-9.pdf

48 AER, *Directive 020*, s. 7.242.

49 AER, *Directive 087: Well Integrity Management*, s. 3.1.

BCER, *Oil and Gas Operations Manual*, s. 9.7.3.

50 AER, *Directive 087*, s. 3.4.31.

51 Seymour et al., "Highly Uncertain Methane Leakage," 13080.

52 AER, "General Well Data." https://www.aer.ca/data-and-performance-reports/activity-and-data/general-well-data

53 BCER, "BCOGC External Reports - SCVF." https://reports.bc-er.ca/ogc/r/app001/ams_reports/scvf?session=11911382867722

54 BCER, "BCOGC External Reports – Gas Migration." https://reports.bc-er.ca/ogc/app001/r/ams_reports/bil-285-gas-migration

This finding could be partly due to wells that have been plugged but not cut and capped (i.e., have not had their casings cut below ground level and steel caps installed) *precisely because* they have unresolved SCVF issues. It could also be due in part to operator failure to update SCVF flow rates after leaks have been resolved.

The data also appears to show that serious leaks go unresolved for years or even decades, despite regulations that require them to be resolved within a reasonable timeframe. These serious and apparently ongoing leaks have been highlighted in a recent media article.[55] The apparent persistence of serious leaks could be due to a failure to resolve them or a failure to report when they have been resolved. If the former is true, it is likely due to the relative difficulty and cost of resolving some instances of SCVF; if the latter is true, it shows a need for improved reporting practices and data quality.

For example, our review of the data found one well in B.C. that was tested nine times from 2008 to 2023, and while the gas flow decreased significantly, the well continues to be classified as having a serious leak (Table 4 in Appendix A). The well in question is plugged but not cut and capped.[56] This suggests that there may have been multiple repair attempts and difficulty resolving the SCVF. At any rate, the SCVF should be resolved before the well is cut and capped.

In Alberta, the number of unresolved cases of reported SCVF and GM has been continuously growing, rising from over 4,000 in 2010 to over 10,000 in 2023.[57] Alberta's cumulative number of serious and unresolved cases of GM has been increasing each year.[58]

### 2.3.1 Summary of problems with the data

- In theory, SCVF is to be resolved at abandonment by identifying and mitigating leakage pathways; abandoned wells therefore should not (as a rule) leak.[59] However, we found thousands of entries showing SCVF at abandoned wells.

[55] Matt Simmons, "44 'Serious' Leaks Reported at B.C. Oil and Gas Sites in the Past Year," *The Narwhal*, March 21, 2025. https://thenarwhal.ca/bc-oil-and-gas-sites-serious-leaks/

[56] BCER, "Metadata for Well Codes." https://www.bc-er.ca/files/gis/WELLCODE_METADATA.pdf

[57] AER, *ST60B-2024: Upstream Petroleum Industry Emissions Report* (2025), Table 13. https://static.aer.ca/prd/documents/sts/ST60-B-2024.pdf

[58] Abboud et al., "Fugitive Methane Gas Migration."

[59] AER, *Directive 087*, s. 3.4.

BCER, *Oil and Gas Operations Manual*, s. 9.7.4. https://www.bc-er.ca/files/operations-documentation/Oil-and-Gas-Operations-Manual/ogaom-chapter-9.pdf

- If SCVF is resolved at abandonment and the well is properly plugged, the leak rate should be zero. Yet most abandoned well records report the same leak rate that was measured prior to repair and abandonment. This suggests that the reported leak rate is not being updated after repairs are made, and the data therefore paints an inaccurate picture.
- Alberta does not require the reporting of negative SCVF tests (tests where no emissions were detected), while B.C. does.[60] This inflates the mean SCVF rate for Alberta compared to B.C. Greater reporting standardization is needed.
- In Alberta, producers are required to measure the rate of detected SCVF and state whether the leak is serious or not, but reporting the precise leak rate is voluntary.[61] Therefore, thousands of suspended and abandoned wells in Alberta have no submitted flow rates. This renders the reported data mostly unusable without additional assumptions.
- Alberta recommends but *does not require* SCVF testing before a well is suspended, while B.C. requires it.[62] This means that operators in Alberta submit data less frequently than those in B.C.
- There appear to be SCVFs for abandoned wells that are emitting indefinitely. It is unclear whether this is due to challenges completing repairs or failures to properly update SCVF rates and other reporting fields after resolving leaks.

Other analyses have similarly identified problems with the SCVF and GM data. For instance, one study revealed that 68% of abandoned wells found to be emitting in Alberta were either not listed in the Alberta Energy Regulator's SCVF and GM database, or were listed as remediated or died out (i.e., the leak gradually dwindled on its own).[63] Another study found over 130 examples of measured leaks that were missing from industry reports.[64] The reported data was also missing key information such as repair dates.[65]

Data collection and management should be improved to ensure that leak reports are updated to reflect the true situation in the field. If leaks are resolved and testing indicates a flow rate of zero, then that is what should be recorded. If serious leaks are resolved, then their status should

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[60] AER, *Directive 087,* s. 3.2.1.

BCER, *Oil and Gas Operations Manual*, s. 9.7.3.

[61] AER, *Directive 087,* s. 3.3.

[62] AER, *Directive 087*, s. 3.2.1.

BCER, *Oil and Gas Operations Manual*, s. 9.7.3.

[63] Bowman et al., "Methane from Abandoned Wells in Alberta and Saskatchewan," 19598.

[64] Seymour et al., "Highly Uncertain Methane Leakage," 13078.

[65] Seymour et al., "Highly Uncertain Methane Leakage," 13082.

likewise be updated. We need a clearer picture of which types of wells leak, how much, for how long, and whether and how quickly serious issues are resolved.

## 2.4 Policy recommendation #1

### Disincentivize long-term well inactivity and improve leak databases

- Limit the amount of time wells can be suspended by mandating abandonment timelines and/or limiting the duration of suspension licences (with potential exemptions or extensions for wells that are especially difficult to repair).
- Implement quotas for reducing inactive and suspended wells and/or significantly increase the amount licensees are required to spend annually on well closures.
- Require SCVF and GM testing at regular intervals during well inactivity and suspension, as well as upon abandonment.
- Require all leaks to be addressed in a timely manner, with clearly defined timelines for repair attempts.
- Enforce repair timelines by issuing fines when operators fail to make good-faith attempts at repair within the allotted timeframe.
- Ensure that levy fees collected and/or security bonds posted are adequate to cover the true cost of abandonment and reclamation.
- Improve data collection and management to ensure SCVF and GM data is accurate, up to date, and standardized across jurisdictions.

# 3. Academic studies – Analysis and recommendations

## 3.1 Flawed official records

### 3.1.1 Count and status of wells

Continuing the theme of poor data, academic studies show that other official records for non-producing wells across jurisdictions in both Canada and the U.S. are likewise flawed.

Numbers of documented wells are sometimes highly inaccurate. For instance, in the U.S., there are roughly 120,000 documented orphaned wells, but studies estimate that the actual number may be closer to 1 million.[66]

Official records of well status (idle, suspended, abandoned, or orphaned) can also be inaccurate. A measurement study conducted in Texas found several wells that were classified as inactive — including wells classified as plugged and abandoned — that were actively producing.[67]

Undercounting and misclassifying wells can create significant uncertainty when estimating emissions from non-producing wells.[68] The assumptions used to handle unclear or missing data substantially impact estimated emissions. Because different governments and regulators use different assumptions, methane inventories have begun to "fundamentally disagree in magnitude and trend," which means stakeholders lack a shared basis for assessing the problem.[69] Poor data also makes it hard to narrow estimates of economic liabilities, set policy priorities, and design efficient mitigation strategies.

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[66] Gianoutsos, Nicholas, Karl Haase, and Justin Birdwell, "Geologic Sources and Well Integrity Impact Methane Emissions from Orphaned and Abandoned Oil and Gas Wells," *Science of The Total Environment* 912 (2024), 1. https://doi.org/10.1016/j.scitotenv.2023.169584

[67] Townsend-Small, Amy, Abigail Edgar, Julianne Fernandez, et al., "High Rates of Hydrogen Sulfide Emissions Measured from Marginal Oil Wells near Austin and San Antonio, Texas," *Environmental Research Communications* 6, no. 9 (2024), 4. https://doi.org/10.1088/2515-7620/ad75f0

[68] O'Malley, Daniel, Andrew Delorey, Eric Guiltinan, et al., "Unlocking Solutions: Innovative Approaches to Identifying and Mitigating the Environmental Impacts of Undocumented Orphan Wells in the United States," *Environmental Science & Technology* 58, no. 44 (2024). https://doi.org/10.1021/acs.est.4c02069

[69] Seymour et al., "Highly Uncertain Methane Leakage," 13079.

### 3.1.2 Characterization of well attributes

Non-producing wells have a number of attributes that may — or may not[70] — be predictors of methane emissions, and yet these attributes are poorly characterized. Well attributes include type (oil or gas), depth, and last production date.[71] A study of official well data found that about 37% of the documented wells in Canada were of an unknown type.[72] Robust, granular data describing key characteristics of wells is needed across producing regions.[73] This data can be gleaned from historical documents, digital databases, and field investigations.[74]

### 3.1.3 Estimation and reporting of emissions

Measurement studies consistently show that methane emissions for upstream oil and gas production are significantly underestimated and underreported.[75] Studies show the same is true of non-producing wells.

A recent study found that methane emissions from non-producing wells in Canada are seven times higher than estimated in Canada's national greenhouse gas inventory report and account for 13% of leaks from oil and gas systems.[76] Other previous studies also found that past national inventories underestimated emissions from non-producing wells.[77] This trend has been found across Canada, from northeastern B.C.,[78] to Alberta and Saskatchewan,[79] through to Ontario.[80]

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[70] El Hachem et al., "Review of Leakage Drivers."

[71] Boutot, Jade, Adam Peltz, Renee McVay, et al., "Documented Orphaned Oil and Gas Wells Across the United States," *Environmental Science & Technology* 56, no. 20 (2022), 14234. https://doi.org/10.1021/acs.est.2c03268

[72] Williams et al., "Methane from Abandoned Wells in Canada and the U.S.," 567.

[73] Klotz, Louise et al., "Sevenfold Underestimation," 9008.

[74] Kang, Mary, Shanna Christian, Michael Celia, et al., "Identification and Characterization of High Methane-Emitting Abandoned Oil and Gas Wells," *Proceedings of the National Academy of Sciences* 113, no. 48 (2016), 13636. https://doi.org/10.1073/pnas.1605913113

[75] MacKay, Katlyn, Martin Lavoie, Evelise Bourlon, et al., "Methane Emissions from Upstream Oil and Gas Production in Canada Are Underestimated," *Scientific Reports* 11, no. 1 (2021). https://doi.org/10.1038/s41598-021-87610-3

[76] Klotz et al., "Sevenfold Underestimation."

Bowman, Lauren, Khalil El Hachem, and Mary Kang, "Methane Emissions from Abandoned Oil and Gas Wells in Alberta and Saskatchewan, Canada: The Role of Surface Casing Vent Flows," *Environmental Science & Technology* 57, no. 48 (2023), 19598. https://doi.org/10.1021/acs.est.3c06946

[77] Williams et al, "Methane from Abandoned Wells in Canada and the U.S., 568.

[78] Pozzobon, Cassandra, Yajing Liu, James Kirkpatrick, et al., "Methane Emissions from Non-Producing Oil and Gas Wells and the Potential Role of Seismic Activity: A Case Study in Northeast British Columbia, Canada," *Environmental Science & Technology* 57, no. 51 (2023). https://doi.org/10.1021/acs.est.3c06062

[79] Bowman et al., "Methane from Abandoned Wells in Alberta and Saskatchewan," 19598.

[80] El Hachem et al, "Methane and Hydrogen Sulfide Emissions."

El Hachem et al., "Multifaceted Environmental Risks."

### 3.1.4 Policy recommendation #2

#### Improve measurement, monitoring, reporting, and verification

- Support initiatives to locate undocumented wells and characterize well attributes.
- Require leak monitoring at suspended and downhole abandoned wells (i.e., those with legacy surface infrastructure) to confirm long-term repair effectiveness and detect new leaks.
- Fund regional measurement and monitoring initiatives to collect representative emissions data at non-producing wells.
- Ensure reporting standards require adequately fine-grained data and measurement.
- Integrate measurement data into emissions inventories.
- Perform quality control audits on submitted well and leak data to reduce the amount of incomplete and inaccurate records.
- Ensure that all data is publicly transparent, especially when data collection is publicly funded.

## 3.2 Extreme uncertainty, variation and distribution

### 3.2.1 Magnitude

The magnitude of methane emissions from non-producing wells is highly uncertain.[81] Measurement research on these wells tends to be piecemeal because the wells can be remote, spread out over large distances, difficult to locate (especially when cut and buried), and generally inaccessible to researchers.

Leaks can also be difficult to detect if they occur in the subsurface or at low rates that can only be detected by highly sensitive equipment at close range. Non-producing wells also differ widely when it comes to key attributes. These differences make it especially challenging to get representative samples.

Current estimates indicate that emissions from individual non-producing wells are typically low but could be significant in aggregate. For instance, a study that analyzed methane measurement data from non-producing wells in Canada found that plugged wells leak on average 1 gram of

[81] Williams et al., "Methane from Abandoned Wells in Canada and the U.S.," 568.

methane per hour and unplugged wells leak 8.3 grams per hour.[82] When comparing to what can be detected by various monitoring technologies, these are low leak rates. For instance, 8.3 grams per hour is about 120 times lower than what can be detected by airplane.[83]

## Limits of aerial measurement

The British Columbia Energy Regulator (BCER) surveyed fully abandoned (decommissioned) wells in northeastern B.C. using sensors attached to a helicopter.[84] Just 1% of the wells initially identified by air were confirmed to be leaking during a follow-up ground survey. On the face of it, the study seems to suggest that abandoned wells are less of a problem in B.C. than in other regions.[85]

However, aerial methods are still limited when it comes to detecting, quantifying and attributing small leaks. In most cases, individual abandoned wells are too small and potentially too diffuse a source of methane emissions to be detectable with aircraft.[86] Close-range methods tend to be more successful at finding small leaks.[87]

Due to the limitations of helicopter surveys in detecting low-level methane emissions, some researchers have pointed out that the B.C. survey likely does not provide "the definitive answer" about emissions from abandoned wells in the region (though the data may be useful in other ways).[88] This shows that when assessing the scope of emissions from non-producing wells, survey methods must be appropriate for the source in question.

[82] Klotz et al., "Sevenfold Underestimation," 9011.

[83] Assuming most aerial measurement technologies can detect down to about 1 kg/hr (1000 g/hr).

[84] BCER, *Multi-year Aerial Leak Survey of Decommissioned Wells* (2024), 7–8. https://www.bc-er.ca/files/reports/Aerial-Leak-Surveys/Multi-year-Aerial-Leak-Survey-of-Decommissioned-Wells.pdf

[85] BCER, *Multi-year Aerial Leak Survey*, 8.

[86] Pekney, Natalie, J. Rodney Diehl, David Ruehl, et al., "Measurement of Methane Emissions from Abandoned Oil and Gas Wells in Hillman State Park, Pennsylvania," *Carbon Management* 9, no. 2 (2018), 165. https://doi.org/10.1080/17583004.2018.1443642

El Hachem, Khalil and Mary Kang, "Reducing Oil and Gas Well Leakage: A Review of Leakage Drivers, Methane Detection and Repair Options" *Environmental Research: Infrastructure and Sustainability* 3, no. 1 (2023), 11. https://doi.org/10.1088/2634-4505/acbced

[87] Pozzobon et al., "Potential Role of Seismic Activity," 21677.

Seymour et al., "Highly Uncertain Methane Leakage," 13083.

[88] Isaac Phan Nay, "B.C. Survey of Abandoned Gas Wells Released to Mixed Reviews," *CBC News*, June 22, 2024. https://www.cbc.ca/news/canada/british-columbia/abandoned-well-survey-1.7242051

You might wonder: if leaks from non-producing wells are so small that they can't be detected by aircraft, then do we really need to care about them? The answer is yes. Even if leaks from individual wells are typically small, small leaks add up if you have enough of them and if they persist over time.

If a significant proportion of Canada's hundreds of thousands of non-producing wells were leaking, total emissions could be significant, especially over time. Given that wells generally do not have to be monitored or tested after abandonment, leaks may be unknown and ongoing.

Researchers estimate that methane emissions from non-producing oil and gas wells in Canada add up to around 230 kilotonnes of methane per year.[89] That's the same carbon footprint as:

- 1.9 billion litres of gasoline consumed
- 9.9 million barrels of oil consumed
- 182.5 million propane cylinders[90]

To put it in the context of fossil fuel production, 230 kilotonnes of methane is more than the fugitive (unintentional) emissions from oil production for the entire province of Alberta in 2023.[91]And leaks do persist over time. Abandoned oil and gas wells can leak for years, even decades.[92] Studies also suggest that high emitters tend to be persistently high[93] over years and likely decades.[94]

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[89] Klotz et al., "Sevenfold Underestimation," 9008.

MacKay, Katlyn, Scott P. Seymour, Hugh Z. Li, et al., "A Comprehensive Integration and Synthesis of Methane Emissions from Canada's Oil and Gas Value Chain: Supplementary Information," *Environmental Science & Technology* 58, no. 32 (2024), S8. https://doi.org/10.1021/acs.est.4c03651

[90] Natural Resources Canada, "Greenhouse Gas Equivalencies Calculator." https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/calculator/ghg-calculator.cfm?_gl=1*jfasmg*_ga*MTg4OTIxMjQ5MC4xNjk1ODUyODE1*_ga_C2N57Y7DX5*MTcxMDk1NzgzMy4xNy4wLjE3MTA5NTc4MzMuMC4wLjA.

[91] Government of Canada*, National Inventory Report 1990–2023: Greenhouse gas sources and sinks in Canada* (2025), Part 3, Annex 11: Provincial and Territorial Greenhouse Gas Emission Tables by IPCC Sector, 1990–2023, Table A11-19. Available at Environment and Climate Change Canada Data Catalogue, "Canada's Official Greenhouse Gas Inventory." https://data-donnees.az.ec.gc.ca/data/substances/monitor/canada-s-official-greenhouse-gas-inventory/A-IPCC-Sector?lang=en

[92] Kang et al., "Identification and Characterization," 13636.

[93] Atherton et al., "Mobile Measurements from Natural Gas Developments in Northeastern B.C.," 12413.

[94] Kang et al., "Identification and Characterization," 13637.

## Marginal wells: Tomorrow's orphans?

Wells that are marginal (low producing) are known to be a disproportionately large source of methane emissions[95] and other hazardous air pollutants,[96] especially relative to their low economic value. Some companies buy these wells at minimal cost to produce their last drops. High liabilities make this business model especially risky, and companies adopting it often go bankrupt, exacerbating the orphan well problem. Mature asset strategies must put measures in place to prevent this, such as measures to ensure that companies reserve adequate capital to cover all liabilities associated with the wells that they purchase. Governments might also consider measures such as methane intensity standards and fees to encourage the abandonment of especially low-producing, high-emitting wells.

### 3.2.2 Variability

If there is one thing that measurement studies of abandoned wells show, it's that the question "how much does an abandoned well emit?" has no single, unqualified answer. Rather, you get a range of answers that depend on where you're looking.

Emissions from abandoned wells vary substantially across regions.[97] For instance, Grande Prairie has been found to have a higher average emissions rate from abandoned wells than other studied regions of Alberta, with average emissions 12 times higher than the next-highest emitting regions of Medicine Hat and Lloydminster (but note that the Grande Prairie sample size was small).[98]

[95] Omara, Mark, Daniel Zavala-Araiza, David Lyon, et al., "Methane Emissions from US Low Production Oil and Natural Gas Well Sites," *Nature Communications* 13, no. 1 (2022). https://doi.org/10.1038/s41467-022-29709-3

[96] Townsend-Small et al., "High Rates of Hydrogen Sulfide."

[97] Klotz et al., "Sevenfold Underestimation," 9011.

Lebel, Eric, Harmony Lu, Lisa Vielstädte, et al., "Methane Emissions from Abandoned Oil and Gas Wells in California," *Environmental Science & Technology* 54, no. 22 (2020), 14624. https://doi.org/10.1021/acs.est.0c05279

Saint-Vincent, Patricia, Matthew Reeder, James III Sams, et al., "An Analysis of Abandoned Oil Well Characteristics Affecting Methane Emissions Estimates in the Cherokee Platform in Eastern Oklahoma," *Geophysical Research Letters* 47, no. 23 (2020), 8. https://doi.org/10.1029/2020GL089663

Townsend-Small, Amy, Thomas Ferrara, David Lyon, et al., "Emissions of Coalbed and Natural Gas Methane from Abandoned Oil and Gas Wells in the United States," *Geophysical Research Letters* 43, no. 5 (2016), 2286. https://doi.org/10.1002/2015GL067623

Williams et al., "Methane from Abandoned Wells in Canada and the U.S.," 567.

[98] Bowman et al., "Methane from Abandoned Wells in Alberta and Saskatchewan," 19579.

Leak types also vary by region. For instance, leak rates from surface casing vents were higher on average than from non-surface casing vents in Alberta but lower in Saskatchewan.[99]

Significant variability in leak rates has also been found within sedimentary basins, leading researchers to conclude that basin alone isn't an adequate predictor of methane emission rates from abandoned wells.[100] Thus, when characterizing leak risks, a number of factors need to be considered, including local geology, regulations, production history, well types, and fluid types.[101]

## Variation over time

One of the key characteristics of methane emissions from oil and gas production is that leaks — particularly the largest, rarest leaks — tend to be intermittent. Large swings in emission rates and volumes can occur within minutes or hours. This can make it challenging to get a representative sample when using snapshot measurements.

Continuous monitoring, which involves fixed sensors that detect and quantify emissions at regular intervals, can help characterize how emissions evolve over time. A study that deployed continuous monitoring for one year at abandoned wells in the U.S. and U.K. found that methane emissions varied by 18 times on average over the course of 24 hours.[102] However, another study found that emission rates at the highest emitters stayed the same over two years of measurement.[103] This underscores the need for more sampling of abandoned and other non-producing wells to determine whether and under what conditions emissions vary over time. Continuous monitoring could play a greater role as the technology continues to improve and costs decline.

[99] Bowman et al., "Methane from Abandoned Wells in Alberta and Saskatchewan," 19579.

[100] Saint-Vincent et al., "Characteristics Affecting Methane Emissions in the Cherokee Platform," 2.

[101] DiGiulio et al., "Chemical Characterization."

[102] Riddick, Stuart, Denise Mauzerall, Michael Celia, et al., "Variability Observed over Time in Methane Emissions from Abandoned Oil and Gas Wells," *International Journal of Greenhouse Gas Control* 100 (2020), 6. https://doi.org/10.1016/j.ijggc.2020.103116

[103] Kang et al., "Identification and Characterization," 13636.

### 3.2.3 Distribution

Methane emissions from oil and gas production are often described as following an "extreme distribution," in which a relatively small number of sources are responsible for a significant proportion of emissions and pull up average emissions. Studies show that methane emissions from abandoned wells likewise follow extreme distributions.[104]

The top 10% of abandoned oil and gas wells in Canada and the U.S. are responsible for 96% of total emissions from abandoned wells.[105] For instance, one unplugged non-producing well in Alberta was leaking enough gas per year to heat an average Canadian home for nearly 34 years,[106] setting the record for highest recorded leak rate from an unplugged well in North America.[107]

Given their disproportionate contribution to methane emissions, high-emitting wells are important targets for mitigation and can be identified readily by a range of measurement technologies, including infrared cameras, vehicle-based systems and methane-sensing aircraft. While satellites play an important role in emissions monitoring by providing independent global coverage, even the highest-emitting abandoned wells generally emit at rates below the detection limits of current satellite systems. There are also challenges detecting emissions in high-latitude areas with cloud cover.[108] That said, the detection capabilities of methane-sensing satellites are likely to improve in the future. In the meantime, satellites can detect wellheads and monitor vegetative health, which can aid in identifying undocumented wells and environmental contamination.[109]

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[104] El Hachem et al., "Multifaceted Environmental Risks," 5.

Kang et al., "Identification and Characterization," 13636.

Lebel et al., "Methane from Abandoned Wells in California," 14622.

Pozzobon et al., "Potential Role of Seismic Activity," 21676.

Riddick, Stuart, Mercy Mbua, Arthur Santos, et al., "Methane Emissions from Abandoned Oil and Gas Wells in Colorado," *Science of the Total Environment* 922 (2024), 3. https://doi.org/10.1016/j.scitotenv.2024.170990

Williams et al., "Methane from Abandoned Wells in Canada and the U.S.," 566.

[105] Gianoutsos et al., "Geologic Sources," 1.

Williams et al., "Methane from Abandoned Wells in Canada and the U.S.," 566.

Williams, James, David Risk, Alexander Marshall, et al., "Methane Emissions from Abandoned Coal and Oil and Gas Developments in New Brunswick and Nova Scotia," *Environmental Monitoring and Assessment* 191, no. 8 (2019), 566. https://doi.org/10.1007/s10661-019-7602-1

[106] Andrew Nikiforuk, "Alberta Sets a Methane 'Super-Emitter' Record," *The Tyee*, December 11, 2023. https://thetyee.ca/News/2023/12/11/Alberta-Methane-Super-Emitter/

[107] "Alberta Sets a Methane 'Super-Emitter' Record."

[108] Sherwin, Evan D., Sahar H. El Abbadi, Philippine M. Burdeau, et al., "Single-Blind Test of Nine Methane-Sensing Satellite Systems from Three Continents," *Atmospheric Measurement Techniques* 17, no. 2 (2024). https://doi.org/10.5194/amt-17-765-2024

[109] Galaszkiewicz et al., "Identifying Sulphurous Water Discharge," 1–2.

When satellites identify high-emitting abandoned wells, the challenge is to ensure that the data yields action. Currently, if a third party detects well methane leaks, there is no pathway to get the data to the relevant operator Emissions need to be correctly attributed, relevant operators notified, and leaks repaired within a reasonable timeframe. Third parties should also be required to notify regulators of detections for potential compliance and enforcement purposes.

The extreme distribution of methane emissions from abandoned wells means two things. First, the more you sample, the more likely you are to find the worst polluters. Finding them and accounting for their emissions is key to ensuring that methane inventories are accurate. Second, efficient strategies can be designed that target a small percentage of abandoned wells but mitigate a large proportion of total emissions from abandoned wells.

Policies should prioritize identifying and mitigating the high emitters. Alberta recently introduced a nomination process whereby landowners, municipalities, and other stakeholders can nominate wells for closure.[110] Successful implementation of this program will require nominated wells to be assessed, plugged and reclaimed in a timely manner. The program will address wells that have been nominated, but this will only identify a portion of problem wells. Therefore, a program like this one should be complementary to other programs and policies to find and remediate problem wells.

Although thus far in this subsection we have been talking about leaks to the atmosphere, it is important not to forget about subsurface leaks. The wells with the highest detected emissions may not be the wells with the most subsurface leakage.[111] Focusing only on mitigating high emissions risks overlooking subsurface leaks and their impacts on groundwater.[112] Monitoring programs therefore need to include measurement techniques that detect emissions and techniques that can detect subsurface leaks (like subsurface measurement and well integrity assessments).[113]

## 3.2.4 Policy recommendation #3

### Tailor methane mitigation to the regional context

- Collect regional data on attributes of and emissions from non-producing wells.
- Correlate well attributes with leak data to determine regional trends.

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110 AER, "Closure Nomination." https://www.aer.ca/regulations-and-compliance-enforcement/liability-management-programs/closure-nomination

111 Bowman et al., "Methane from Abandoned Wells in Alberta and Saskatchewan," 19599.

112 Kang et al., "Environmental Risks and Opportunities," 8.

113 Schout et al., "Occurrence and Fate," 779.

- Tailor mitigation strategies to regional trends.
- Leverage a range of complementary tools and strategies to identify problem wells, such as diverse methane measurement methods, vegetation monitoring with satellites, public complaint records, and closure nominations.
- Develop measurement and monitoring programs that incorporate close-range methods capable of detecting small leaks and potential subsurface leakage.
- Design stringent monitoring and follow-up requirements for known problem wells.

## 3.3 Risk factors

Studies have identified several factors that can be associated with an increased risk of leaks at non-producing wells. However, risk factors can vary across regions.[114] Further research is needed to characterize region-specific risk factors. The following subsections discuss some potential candidates.

### 3.3.1 Type

Abandoned gas wells emit more compared to abandoned oil wells, coal seams, and methane produced by bacteria in soil.[115] One study found that, on average, they emit at twice the rate of oil wells,[116] and another found that they made up most of the high-emitting wells measured.[117]

Researchers have also considered whether different extraction methods have different leak potentials. For instance, in areas such as B.C.'s Montney Formation where oil and gas do not flow easily, techniques such as horizontal drilling and hydraulic fracturing ("fracking") are needed.

The concern with fracked wells is the potential for reduced well integrity.[118] A small measurement study of 10 abandoned wells in the B.C. Montney area (nine of which were fracked wells) found that five showed signs of integrity loss.[119] The fracking process involves injecting fluids at high pressures in multiple stages, which can repeatedly stress the well materials and

[114] El Hachem et al., "Review of Leakage Drivers," 5.

[115] Gianoutsos et al., "Geologic Sources,", 1.

[116] Williams et al., "Methane from Abandoned Wells in Canada and the U.S," 567.

[117] Bowman et al., "Methane from Abandoned Wells in Alberta and Saskatchewan," 19597.

[118] Ingraffea, Anthony, Martin Wells, Renee Santoro, et al., "Assessment and Risk Analysis of Casing and Cement Impairment in Oil and Gas Wells in Pennsylvania, 2000–2012," *Proceedings of the National Academy of Sciences* 111, no. 30 (2014). https://doi.org/10.1073/pnas.1323422111

[119] Cahill et al., "Decommissioned Unconventional Wells in B.C.," 1.

create pathways for leaks.[120] The process can also cause earthquakes,[121] which may likewise compromise well integrity. Higher methane emission rates have been observed at wells near earthquake epicenters, especially at plugged wells.[122] Fracking is also used to produce gas from shale formations. Following abandonment of shale gas wells, significant gas reserves can remain, which means methane may slowly leak over long periods of time.[123] Shale gas wells were found to have cement or casing problems six times more frequently than conventional wells.[124] Proximity to fracking is likewise associated with elevated concentrations of methane in groundwater aquifers.[125]

Other features of wells can affect leakage, such as depth[126] and the straightness of the well path.[127]

Features of the reservoir itself, such as remaining gas, pressure, and depth, can also affect leak rates.[128] Shallow reservoirs have a greater risk of leakage.[129] And leak rates are much higher when there is a lot of gas remaining in the reservoir after a well stops producing.[130]

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[120] Cahill et al., "Decommissioned Unconventional Wells in B.C.," 2.

[121] Pozzobon et al., "Potential Role of Seismic Activity," 21676.

[122] Pozzobon et al., "Potential Role of Seismic Activity," 21673.

[123] Yang, Yun, Shimin Liu, and Haoming Ma, "Impact of Unrecovered Shale Gas Reserve on Methane Emissions from Abandoned Shale Gas Wells," *Science of The Total Environment* 913 (2024). https://doi.org/10.1016/j.scitotenv.2023.169750

[124] Ingraffea et al., "Casing and Cement Impairment," 10955.

[125] Ingraffea et al., "Casing and Cement Impairment," 10955.

[126] Saint-Vincent et al., "Characteristics Affecting Methane Emissions in the Cherokee Platform," 7. https://doi.org/10.1029/2020GL089663

[127] El Hachem et al., "Review of Leakage Drivers," 4–5.

Watson, Theresa and Stefan Bachu, "Evaluation of the Potential for Gas and CO2 Leakage Along Wellbores," *SPE Drilling & Completion* 24, no. 01 (2009), 121. https://doi.org/10.2118/106817-PA

[128] El Hachem et al., "Review of Leakage Drivers," 4.

[129] Moghadam, Al, Elisabeth Peters, and Susanne Nelskamp, "Gas Leakage from Abandoned Wells: A Case Study for the Groningen Field in the Netherlands," *International Journal of Greenhouse Gas Control* 126 (2023), 1. https://doi.org/10.1016/j.ijggc.2023.103906

Watson et al., "Potential for Gas and CO2 Leakage," 124.

[130] Nowamooz, A., J.M. Lemieux, J. Molson, et al., "Numerical Investigation of Methane and Formation Fluid Leakage along the Casing of a Decommissioned Shale Gas Well," *Water Resources Research* 51, no. 6 (2015), 4615. https://doi.org/10.1002/2014WR016146

Moghadam et al., "Case Study for the Groningen Field," 1.

### 3.3.2 History

It is intuitive to think that the older the well, the more likely it is to decay and leak. Surprisingly, greater well age does not generally correlate with greater emissions.[131] However, some studies show that the construction period of the well[132] and, relatedly, its regulatory history can be correlated with leak risk. Relevant regulatory history might include whether the well was drilled and abandoned before requirements for plugging,[133] the codification of modern plugging standards,[134] or requirements for SCVF and GM testing.[135]

The history of leaks during a well's life is also a potential indicator of leak risk post-abandonment.[136] This is further reason why accurate, comprehensive and complete data is important. Such data, including any history of serious or recurring leaks, should be used to assess the leak risk of non-producing wells.

How recently production ended can be an additional risk factor. Emissions can peak in the early years after abandonment, typically within a decade.[137] One study found that recently producing orphaned wells emit on average 1000 times more per hour than other orphan wells.[138] This means that more frequent monitoring may be justified in the years immediately following production.

[131] Kang et al., "Identification and Characterization."

Riddick, Stuart, D.L. Mauzerall, M.A. Celia, et al., "Measuring Methane Emissions from Abandoned and Active Oil and Gas Wells in West Virginia," *Science of the Total Environment*, 651, Pt 2 (2019). https://doi.org/10.1016/j.scitotenv.2018.10.082

Saint-Vincent et al., "Characteristics Affecting Emissions in the Cherokee Platform," 7.

Townsend-Small et al., "High Rates of Hydrogen Sulfide," 5.

[132] El Hachem et al., "Review of Leakage Drivers," 2.

[133] Townsend-Small et al., "Coalbed and Natural Gas Methane," 2287.

[134] El Hachem et al., "Methane and Hydrogen Sulfide Emissions."

[135] Watson, "Potential for Gas and $CO_2$ Leakage," 118.

[136] Cahill et al., "Optimizing Well Plug and Abandonment," 2.

[137] Boothroyd, I., S. Almond, S. Qassim, et al., "Fugitive Emissions of Methane from Abandoned, Decommissioned Oil and Gas Wells," *Science of The Total Environment* 547 (2016), 461 & 468. https://doi.org/10.1016/j.scitotenv.2015.12.096

Williams et al., "Abandoned Developments in New Brunswick and Nova Scotia," 479.

[138] Mark Jaffe, "Super-emitting' oil wells near Denver are releasing 142% more pollution per hour than state average, CSU study finds," *The Colorado Sun*, October 23, 2023. https://coloradosun.com/2023/10/23/methane-emissions-super-emitting-oil-gas-adams-county/

### 3.3.3 Status

Some well statuses are associated with more emissions than others. Being orphaned may lead to greater methane emissions,[139] because orphaned wells are more likely to be unplugged, unremediated, or in a state of disrepair. These wells are typically orphaned precisely because their owners cannot afford the economic liabilities associated with proper abandonment and reclamation and become insolvent. Since orphaned wells are relatively understudied due to poor recordkeeping and difficulties with site access, more research is needed to characterize emissions from them.

Inactive wells emit methane[140] and can emit more than properly abandoned wells.[141] This is probably due to the broader fact that inactive wells are unplugged, and therefore tend to emit more on average than abandoned wells, which are more likely to be plugged.[142] Just how much more they emit likely depends on the region and the stringency of plugging standards.

For instance, plugged wells in regions with stringent plugging standards, such as Colorado, have been found to have negligible emissions.[143] By contrast, a study of abandoned wells in Oklahoma found no statistically significant difference between emission rates from plugged and unplugged abandoned wells — but that unplugged wells were more likely to be leaking and tended to be a greater source of chronic methane emissions.[144]

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[139] Townsend-Small et al., "Coalbed and Natural Gas Methane," 2287.

[140] Simon Festa-Bianchet, David Tyner, Scott Seymour, et al., "Methane Venting at Cold Heavy Oil Production with Sand (CHOPS) Facilities Is Significantly Underreported and Led by High-Emitting Wells with Low or Negative Value," *Environmental Science & Technology* 57, no. 8 (2023), 3028. https://doi.org/10.1021/acs.est.2c06255

Okorn, Kristen, Amanda Jimenez, Ashley Collier-Oxandale, et al., "Characterizing Methane and Total Non-Methane Hydrocarbon Levels in Los Angeles Communities with Oil and Gas Facilities Using Air Quality Monitors," *Science of The Total Environment* 777 (2021). https://doi.org/10.1016/j.scitotenv.2021.146194

[141] Lebel et al., "Methane from Abandoned Wells in California."

[142] Bowman et al., "Methane from Abandoned Wells in Alberta and Saskatchewan," 19597.

El Hachem et al., "Multifaceted Environmental Risks," 5.

Kang et al., "Identification and Characterization," 13636.

Riddick et al., "Methane from Abandoned Wells in Colorado."

Riddick et al., "Methane from Wells in West Virginia."

Saint-Vincent, Patricia, James III Sams, Matthew Reeder, et al., "Historic and Modern Approaches for Discovery of Abandoned Wells for Methane Emissions Mitigation in Oil Creek State Park, Pennsylvania," *Journal of Environmental Management* 280 (2021). https://doi.org/10.1016/j.jenvman.2020.111856

Saint-Vincent et al., "Characteristics Affecting Methane Emissions in the Cherokee Platform."

Townsend-Small et al., "Coalbed and Natural Gas Methane."

[143] Riddick et al., "Methane from Abandoned Wells in Colorado."

[144] Saint-Vincent et al., "Characteristics Affecting Methane Emissions in the Cherokee Platform," 6.

### "Unplugged abandoned well": a contradiction in terms?

In some jurisdictions, such as Alberta, to be considered abandoned, wells must be plugged. However, not all jurisdictions narrowly define what it means to be abandoned. In other places, abandoned just means non-producing, and wells can be both unplugged and abandoned. This difference in terminology creates substantial confusion.

Still, it is important to note that plugged wells can leak. According to aerial surveys of plugged abandoned wells in B.C., 5% of surveyed wells showed signs of well integrity failure.[145] This likely underrepresents the number of failures since subsurface leaks are often not detectable from the air. Leaks from plugged abandoned wells can be due to damaged or deteriorating surface and subsurface infrastructure,[146] as well as issues with well and plugging materials.

## 3.3.4 Materials

Cement is used as a sheath along oil and gas wellbores and as a plugging material. Leaks can arise due to insufficiently placed or incorrectly poured cement plugs,[147] debonding of cement from the casing[148], and problems with cement setting,[149] as well as low-quality casing and poorly welded casing caps.[150] Cement sheathing with high permeability is also a significant risk factor[151] and can result in leaks within a year of well closure.[152]

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[145] Cahill et al., "Optimizing Well Plug and Abandonment," 58.

[146] Gianoutsos et al., "Geologic Sources," 1–2.

[147] Kuip, M. D. C. van der, T. Benedictus, N. Wildgust, et al., "High-Level Integrity Assessment of Abandoned Wells," *Energy Procedia, 10th International Conference on Greenhouse Gas Control Technologies*, 4 (2011). https://doi.org/10.1016/j.egypro.2011.02.513

Saint-Vincent et al., "Characteristics Affecting Methane Emissions in the Cherokee Platform," 2.

[148] El Hachem et al., "Review of Leakage Drivers," 12.

[149] Kevin Macedo, Jason Schneider, Chuck Sylvesre, et al., "Elimination of Surface Casing Vent Flow and Gas Migration in the Lloydminster Area," *SPE Heavy Oil Conference Canada* (2012). https://onepetro.org/SPECHOC/proceedings-abstract/12IHOC/All-12IHOC/SPE-157922-MS/158925

[150] Boothroyd et al., "Fugitive Emissions from Abandoned, Decommissioned Oil and Gas Wells," 462.

El Hachem et al., "Review of Leakage Drivers," 4.

Ingraffea et al., "Casing and Cement Impairment."

Watson et al., "Potential for Gas and CO2 Leakage," 118.

[151] Cahill et al., "Optimizing Well Plug and Abandonment," 56–57.

Moghadam et al., "Case Study for the Groningen Field," 2.

Nowamooz et al., "Numerical Investigation," 4592.

Watson et al., "Potential for Gas and CO2 Leakage," 123.

[152] Nowamooz et al., "Numerical Investigation," 4618.

### 3.3.5 Policy recommendation #4

#### Characterize and mitigate risks of methane leaks

- Fund efforts to better characterize regional risk factors.
- Consider more stringent monitoring requirements for gas wells, particularly horizontally drilled gas wells and wells in shallow reservoirs, as well as both oil and gas wells in the first decade of post-production.
- Prioritize assessing, plugging and reclaiming wells abandoned before the implementation of testing requirements and modern plugging standards.
- Ensure that drilling and plugging standards require materials of adequate quality to prevent leaks.
- Require testing of wells that may have substandard cementing.

# 4. Conclusion

Canada’s population of non-producing wells is growing, and sound data and policies are needed to ensure that climate and other environmental harms from inactive, suspended, abandoned, and orphaned wells are adequately understood and addressed. Methane emissions from these wells are potentially significant in aggregate — more significant than is recognized in official inventories, though precisely *how* significant relative to major upstream emissions sources depends on the region and features such as local geology and applicable regulations.

There are a range of potential risk factors for leaks, including well type, history, status, and materials. These risk factors need to be better characterized for each region so that regional policies and mitigation strategies can be developed to effectively and efficiently tackle methane emissions. Policies should prioritize moving inactive and suspended wells through to proper abandonment (including addressing methane leaks); improving data reporting and quality; and enhancing measurement, monitoring, and testing requirements.

Based on our assessments of industry reports and academic studies, we have also concluded that the non-producing well problem requires strengthening regulatory oversight, with the regulators’ role clearly defined.

Regulators exist to create and enforce regulations in the public interest. In the case of non-producing wells, regulators should be responsible for protecting the public from the impacts of methane emissions and co-pollutants on air, water, and climate, while also upholding the polluter pays principle. They are responsible for ensuring that the oil and gas industry lives up to its obligation to properly manage legacy assets and return the land to its previous state. To fulfill this responsibility, regulators must be given clear policy direction and adequate capacity.

As Canada’s oil- and gas-producing regions continue to develop policies to address “mature assets,” it is vital that they get it right. While we have shown in this report that methane emissions from non-producing wells are a complex issue, we have also revealed that efficient, effective policy options are available to governments willing to take an evidence-based approach.

# Appendix A. Detailed SCVF and GM data

## A.1 Reported leak rates

In Table 2, we summarize the SCVF and GM data from Alberta and B.C. by gas flow type. Over the timeframe of published data (Alberta's earliest reports are from 1971 and B.C.'s from 1993), around 39,000 and 22,500 well tests have been reported in each province, respectively. Not all of these reports are unique, meaning they do not all come from different wells.

We note that Alberta does not require the reporting of negative SCVF tests (tests where no emissions are detected).[153] Therefore, the number of SCVF tests performed in Alberta over time is probably higher than the reported data suggests.

Table 2. Reported instances of SCVF and GM for Alberta and B.C.

| Flow type | Alberta | | | British Columbia | |
|---|---|---|---|---|---|
| | SCVF | GM | SCVF & GM | SCVF | GM |
| Non-gas flow[a] | 2,325 | 1102 | 40 | 7,810 | 0 |
| Non-serious gas flow | 28,997 | 2,026 | 52 | 12,007 | 161 |
| Serious gas flow | 3,102 | 932 | 451 | 393 | 1 |
| No-emission gas flow | 0 | 0 | 0 | 0 | 275 |
| Unknown gas flow | 0 | 0 | 0 | 1,855 | 0 |
| Total | 34,424 | 4,060 | 543 | 22,065 | 437 |

[a] Non-gas flows may include condensate, crude bitumen, crude oil, hydrocarbon liquid, water, and waste.

Data sources: Alberta Energy Regulator, British Columbia Energy Regulator[154]

For B.C. and Alberta's suspended and abandoned wells with reported tests, there are about 19,000 non-unique well reports and 3,200 unique well reports, for a total of 22,200 reports.

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[153] AER, *Directive 087: Well Integrity Management*, 3.2.1.

[154] AER, *Well Vent Flow/Gas Migration Report* (2025). https://www1.aer.ca/productcatalogue/365.html

BCER, *Gas Migration* (2025). https://reports.bc-er.ca/ogc/app001/r/ams_reports/bil-285-gas-migration

BCER, *Surface Casing Vent Flow* (2025). https://reports.bc-er.ca/ogc/r/app001/ams_reports/scvf?session=2533735858800

There are a high number of total well reports in the B.C. data relative to the number of unique well reports indicates that individual wells often have multiple reports. This reflects a difference in B.C.'s reporting practices for SCVF compared to Alberta, where the number of wells with more than one SCVF report is substantially lower. As of 2024, Alberta and B.C. had about 190,000 non-producing wells in their combined inventories, meaning only 14% of their non-producing wells have had testing reported for SCVF and GM.

Table 3 below summarizes the leak rates that were found for wells of different statuses. As we discuss in Section 2.3, we believe that the data presented here may not represent true leak rates due to data quality issues. Table 3 is therefore intended only as a general summary of the data.

Table 3. SCVF and GM data for Alberta and B.C. by licence status

| License status | Alberta | | British Columbia | |
|---|---|---|---|---|
| | Flow rate ($m^3$/day) | Count | Flow rate ($m^3$/day) | Count |
| Abandoned | 361,510.13 | 9,903 | 65,394.15 | 1507 |
| Abandoned zone[a] | N/A | N/A | 16,692.49 | 1985 |
| Active | 440,405.63 | 9,920 | 46,961.61 | 8782 |
| Suspended | 275,138.64 | 12,049 | 14,238 | 1981 |
| Reclaimed[b] | 116,765.64 | 3,681 | — | — |
| Total | 1,193,820.04 | 35,553 | 143,286.25 | 14,255 |

Data sources: Alberta Energy Regulator,[155] British Columbia Energy Regulator[156]

[a] "Abandoned zone" refers to a well that has accessed multiple formations or zones, and some but not all of them have been isolated and plugged. Alberta does not use this category.

[b] Data not available for B.C.

According to provincial data, the average leak rate for abandoned wells with reported leaks is 36.5 $m^3$/day/well in Alberta and 23.5 $m^3$/day/well in B.C. Given that the average Canadian home uses about 7 $m^3$ of gas per day,[157] if accurate, these reported leak rates represent three to five times the daily gas consumption of an average home. The average reported leak rate for suspended wells was 22.8 $m^3$/day/well in Alberta and 7.2 $m^3$/day/well in British Columbia.

[155] AER, "Well Vent Flow/Gas Migration Report." https://www1.aer.ca/productcatalogue/365.html

[156] BCER, "Well Emissions."

[157] Canadian Gas Association, "Natural Gas Facts." https://www.cga.ca/natural-gas-statistics/natural-gas-facts/

## A.2 Long-term serious leak

Table 4 highlights reported data for an anonymous well in British Columbia that has been tested nine times from 2008 to 2023 — yet it is consistently designated as having a "serious" leak. As we discuss in Section 2.3, it is unclear whether this leak's continued classification as serious is due to stubborn SCVF, reporting error, or issues other than high flow rate.

Table 4. Flow rate from an anonymous well with a designated serious leak in B.C., 2008–2023

| Test year | Flow rate ($m^3$/day) |
|---|---|
| 2008 | 381.0 |
| 2011 | 22.7 |
| 2012 | 35.6 |
| 2013 | 36.1 |
| 2015 | 39.3 |
| 2016 | 50.5 |
| 2020 | 54.0 |
| 2022 | 47.0 |
| 2023 | 52.3 |
| Cumulative total at end of 2023 ($m^3$) | 628,574 |

Data source: British Columbia Energy Regulator[158]

Assuming this well emitted continuously at the rates shown and that the rates can be extrapolated to non-test years, cumulative emissions by the end of 2023 totalled 628,573.8 $m^3$ of natural gas. This is equivalent to approximately 383.6 tonnes of methane emitted from 2008 to the end of 2023, assuming natural gas produced in B.C. is 90% methane. That is enough natural gas to satisfy the annual consumption of 246 Canadian homes.[159]

[158] BCER, "Well Emissions." https://www.bc-er.ca/data-reports/data-narratives/well-emissions/

[159] Canadian Gas Association, "Natural Gas Facts." https://www.cga.ca/natural-gas-statistics/natural-gas-facts/


Photo: Simon Dyer, Pembina Institute

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