BILLION DOLLAR ORPHANS

Why millions of oil and gas wells could become wards of the state

September 2020

Carbon Tracker Initiative

About Carbon Tracker

Carbon Tracker is a team of financial specialists making climate risk real in today's markets. Our research to date on unburnable carbon and stranded assets has started a new debate on how to align the financial system in the transition to a low carbon economy.

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Acknowledgements

We thank the several states that complied with our information requests for bonding data, and Charles Guy-Knapp for his work on procuring this information. We especially thank Theron Horton of the ARO Working Group for insights and development of state bonding data, and Savani Mahoorkar for managing the cost modelling database. The report was reviewed and commented on by Carbon Tracker staff, including: Mike Coffin, Kingsmill Bond, Henrik Jeppesen, Andrew Grant, Joel Benjamin and Daniel Cronin. All errors and omissions are the responsibility of the authors.

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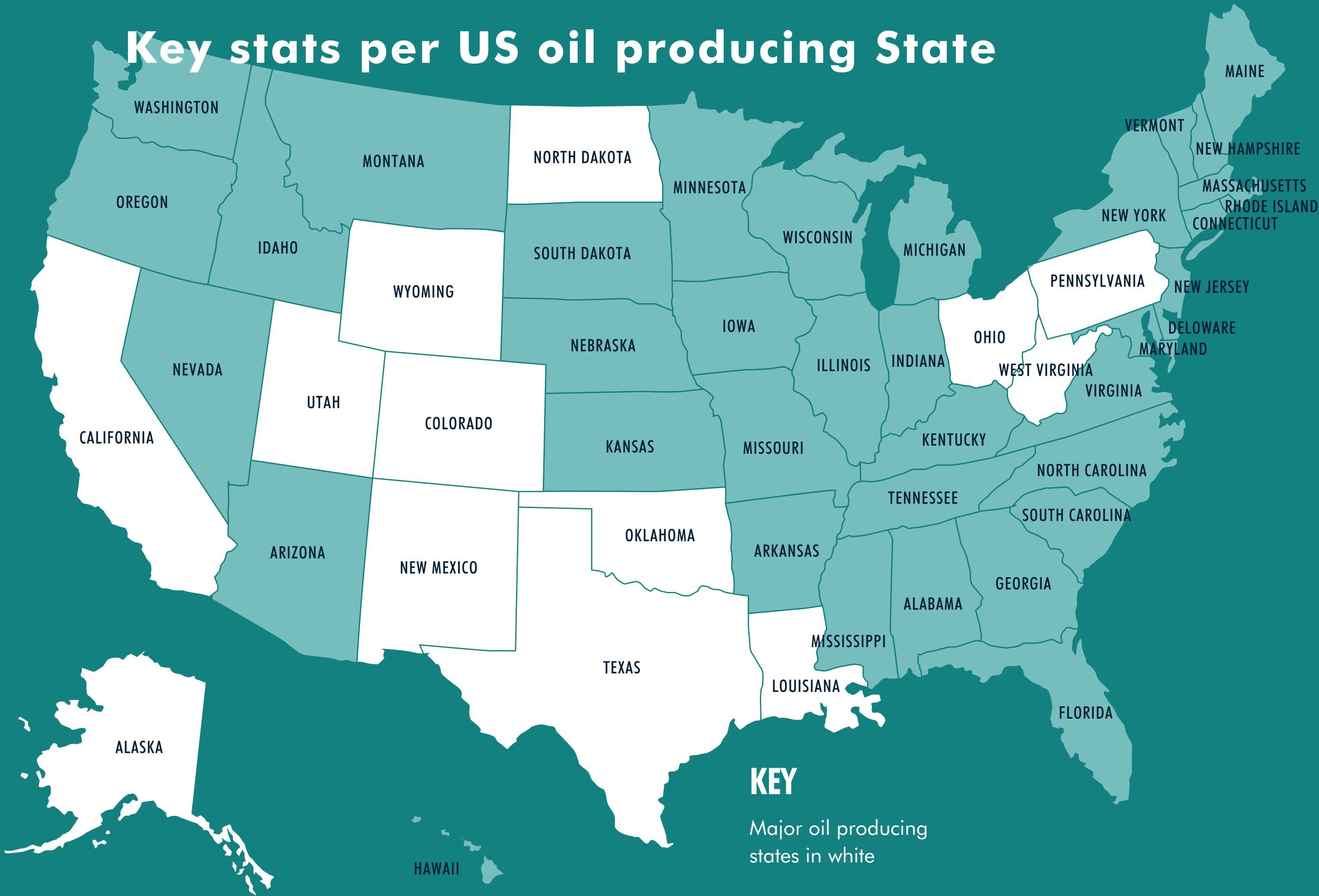
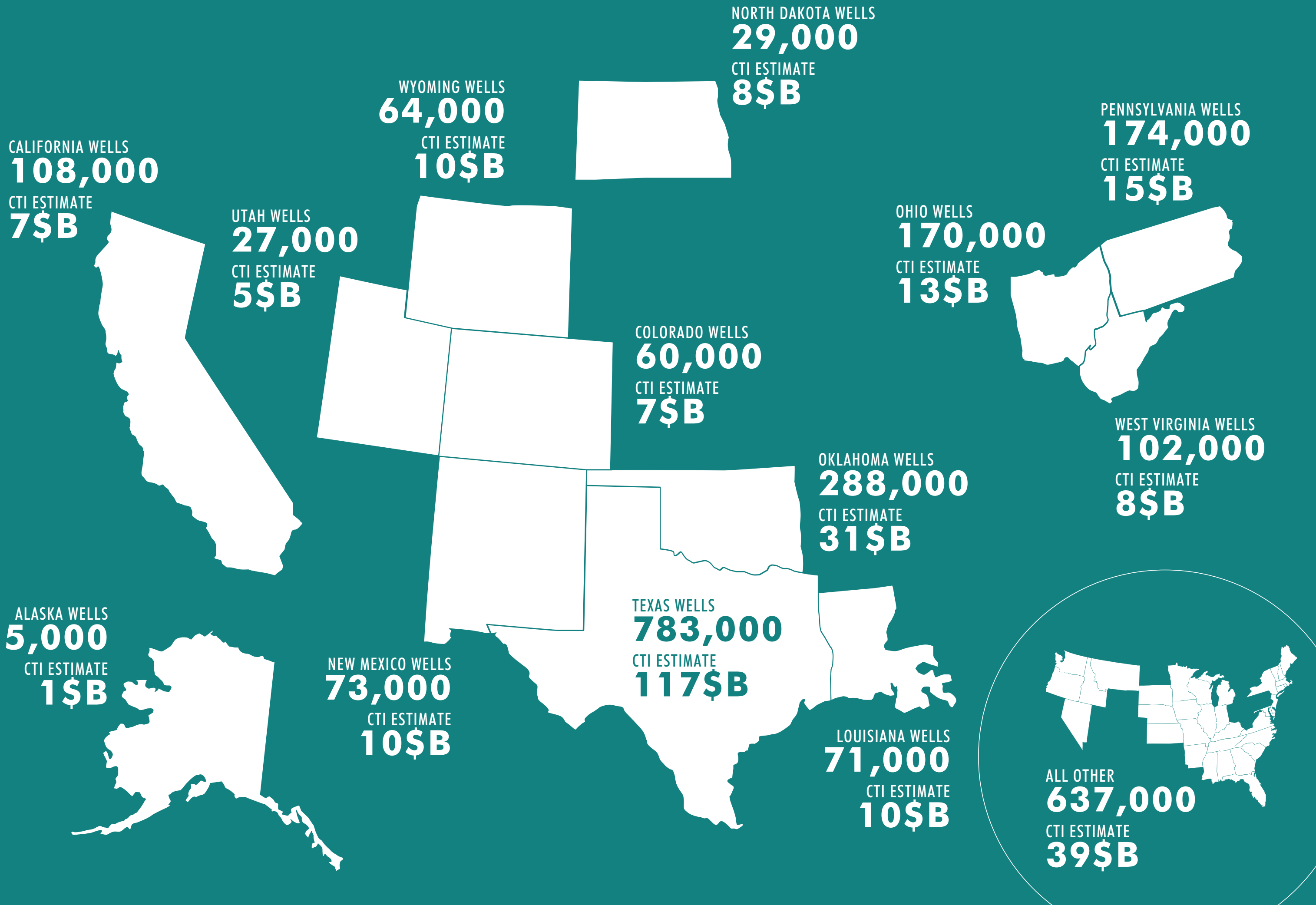
Key stats per US oil producing State



KEY

Major oil producing states in white

CTI ESTIMATE: Potential costs to close orphaned oil and gas wells



Executive Summary

It is said that, "it's never too early to start thinking about retirement". That's especially true for the oil and gas industry and the states that will be left with the bill if they don't save. "Thinking about retirement" means figuring out how much money one will need when paid work ends and finding a way to save it in advance.

Unfortunately, our review suggests states are underestimating what retiring oil and gas wells will cost and have failed to "save" for it by requiring virtually no financial assurance.

We estimate that plugging 2.6 million documented onshore wells in the U.S. alone will cost $280 billion. This estimate excludes costs to plug an additional estimated 1.2 million undocumented onshore wells. Available bonding data suggests that states on average have secured less than 1% of that amount in surety bonds — and that assumes every insurer can and will pay. This means that, as a whole, oil and gas producing states are susceptible to serial operator defaults and exposed to hundreds of billions of dollars in orphan well liability risk.

Moreover, by not requiring the savings, states continue to make matters worse. Failing to require bonding gives operators every incentive to spend on drilling more wells or pay investors first whilst pushing closure costs down the road. Recent bankruptcies are showing the cracks in this system, as some states have thrown in the towel and allowed debtors to abandon unplugged wells to the state.

This outcome is not a foregone conclusion. States can act now to protect their citizens and taxpayers. By increasing bond amounts to reflect actual costs, states can shift financial responsibility to industry where it belongs and simultaneously position themselves to receive U.S. federal aid.

Introduction

The oil and gas data provider, Enverus, lists 2.6 million unplugged onshore wells in the U.S. EPA estimates that there are another 1.2 million undocumented unplugged onshore wells that aren't in the Enverus database.[1]

Of the 2.6 million documented wells, 1.7 million are (or were) hydrocarbon producing wells. Of these, 50% have not produced oil or gas since 2014. What are the odds that these wells will ever be reactivated?

Wells used for related oilfield purposes (e.g., injection, waste disposal, water, monitoring, and even wells classified as "unknown") – about 0.9 million wells in total – comprise the rest. Although these wells are incidental to oil and gas production, and themselves produce no revenue, they must be closed just like producing wells.

In *It's Closing Time,* we explained how the oil and gas industry is legally obligated to plug and abandon (P&A) wells, but it hasn't set aside the resources to do so. Identified operators are associated with 2.1 million of the 2.6 million documented unplugged onshore wells in the U.S. But can these operators afford the cleanup bill, and how much security is available if they default?

Since 1900, according to Enverus, the U.S. oil industry has drilled more than 4.3 million onshore wells. As of 2020, only 1.6 million of these wells have been plugged. Thus, over its 120-year history, the U.S. oil industry has plugged only about one of every three wells drilled, closing roughly 13,000 wells per year, on average. At this pace, assuming the industry never drills another well, it will take over 300 years to plug the nation's 3.8 million unplugged wells. How likely is it that the oil industry will close any wells at all after all drilling stops? With climate scientists warning that the world needs to be carbon neutral by 2050, how likely is that the oil industry will be able to afford the cost to plug 10 times as many wells per year (130,000/year) over the next 30 years?

States have inadvertently created a moral hazard: it's always in the operator's financial interest to delay permanent abandonment of wells as long as possible, often by selling late-life and marginal assets to weaker companies. As a predictable result, inventories of largely self-bonded idle and orphan wells are exploding. This trend will only accelerate as the industry's state of permanent decline continues.

Covid-19 has temporarily shut-in tens of thousands of producing wells, and the energy transition may prevent the reactivation of these and hundreds of thousands more idle wells. The industry's asset retirement obligations (AROs) – the accounting term for P&A liabilities – are accelerating, putting additional pressure on distressed corporate balance sheets.

[1] https://www.epa.gov/sites/production/files/2018-04/documents/ghgemissions_abandoned_wells.pdf.

State estimates of potential orphan well liability risk — often calculated assuming an average cost of $20,000 - $40,000 per well — are far too low. For example, New Mexico's Oil Conservation Division has reported an average cost of $28,000 to plug an orphan well with no spills.[2] We estimate the average cost for industry to plug the 73,000 unplugged wells in New Mexico will be $141,000 per well — five times the state's reported average orphan well plugging cost.

What explains the difference? First, most available cost data is from selective orphan well closures and, as we explained in *It's Closing Time*, industry's costs to plug comparable wells of similar depth at the end of a well's economic life may be much higher than those incurred by state orphan well programs. Second, depth is likely an important component of cost, and modern shale wells are much deeper than typical orphan wells.

As long as industry can afford these obligations, states may have nothing to worry about. The problem is that industry — not just a few insolvent companies but the entire U.S. oil and gas industry — may not have sufficient revenues and savings to satisfy liabilities for closure of millions of wells as they come due. Industry-funded orphan well programs are barely a drop in the bucket, as these are typically funded to close less than 100 wells per year. In 2018, state orphan well programs plugged 2,377 of 56,600 documented orphan wells.[3] At this pace, it would take another 23 years just to plug the remaining documented orphan wells. By comparison, at this pace, it would take state orphan well programs 1,600 years to plug the nation's 3.8 million unplugged wells should they inherit this liability.

States can protect themselves by requiring companies to assure these cleanup costs by requiring operators to purchase surety bonds — just like a mortgage lender might require private mortgage insurance. But state bonding requirements, being based on very low-cost estimates, are woefully insufficient. More than 99% of the estimated closure costs are not covered by existing bonds. In effect, companies are "self-bonded"— that is, states are relying entirely upon the continued financial solvency of the firms' well operators.

Self-bonded AROs have left industry and oil producing states in a deep hole. If millions of wells with no future beneficial value are to be plugged as the law requires, it will mostly be at taxpayer expense. If instead, they are not plugged, the price will be paid by landowners, citizens, and the environment.

By continuing to extend free unsecured credit for oilfield closure liabilities, states are subsidizing oil and gas to the detriment of their citizens, the environment, and the competitiveness of renewable energy needed to combat climate change.

This report aims to quantify the magnitude of the problem for major oil-producing states.

[2] https://www.abqjournal.com/1416207/nm-not-ready-to-restore-lands-if-booms-a-bust.html.
[3] See IOGCC Figure 9. Orphan Wells Plugged in 2018. http://iogcc.ok.gov/Websites/iogcc/images/Publications/2019%2012%2031%20Idle%20and%20Orphan%20oil%20and%20gas%20wells%20-%20state%20and%20provincial%20regulatory%20strategies%20(2019).pdf

Defining orphan well liability risk

We estimate total orphan well liability risk for each major oil producing state in the U.S. We define *orphan well liability risk* as a state's potential costs to close orphaned oil and gas wells, measured as 100% of estimated cost to plug all documented wells in the state, less available bonds.

Orphan wells are non-producing wells that have no known, financially viable, responsible operator capable of plugging the well. Marginally productive active wells and idle wells can become orphans when deserted by a financially insolvent operator. Injection, disposal, and water wells can become orphans when they can no longer service oil and gas production. Responsibilities for plugging and decommissioning these wells will ultimately fall to the state and its taxpayers if operators cannot manage the costs.

It is increasingly clear that many companies cannot pay for clean up. For example, Petroshare Corporation declared bankruptcy in the fall of 2019. Its bankruptcy plan envisions selling its assets to a major creditor and, as part of that plan, it has persuaded the State of Colorado to allow Petroshare's unwanted wells to be abandoned without being plugged, putting the cleanup responsibility on the state.[4]

States have policies in place to protect taxpayers from the potential financial and environmental costs of orphan and idle wells. For example, operators are required to obtain "indemnity" or "surety" bonds — a form of financial assurance — when drilling, reworking, or acquiring a well, to support the cost of plugging a well should it be deserted. Some states also require the operators of idle wells to pay fees or develop management plans to plug and abandon wells that have been idle for several years. States can reduce their orphan well liability risk by increasing financial assurance to cover the costs of closure or reducing inventories of unplugged wells.

Estimating orphan well liability risk

Many factors can impact actual P&A costs, but our model focuses on one key variable — the depth of the well bore. As we showed in *It's Closing Time*, plugging costs are exponentially correlated with well depth, and the estimated cost to plug modern deep shale wells is likely as much as an order of magnitude higher than industry's estimates, which are based on reported costs incurred by states to plug orphan wells.[5] Building upon well depth data from Enverus, our estimates of orphan well liability risk are based on the number and depth of unplugged wells in each state.

Enverus reports a large number of existing unplugged wells in the U.S., ranging from 1,200 in Florida to 800,000 in Texas. Estimated plugging costs per well range from a few thousand dollars to over a million dollars. We have conservatively capped our estimates for ultra-deep wells (wells deeper than 10,000 feet) at the estimated cost to plug a 10,000-foot well, even though it may cost much more to plug these wells. We have not included reclamation costs, though such activities are legally required.

If states have financial assurance covering operator defaults, they are shielded from those defaults. Typically, bond coverage is up to a fixed amount. Therefore, where that data is available, we can calculate total bond coverage per state. In our model, bond coverage per well is expressed as a percentage, and is calculated by dividing each state or operator's total bond amount by the estimated cost to plug and abandon that state or operator's active and idle wells (which, for states, include orphaned wells).

[4] See Blog on Petroshare Corporation https://carbontracker.org/petroshare-gets-the-oil-and-colorado-the-hole/
[5] Darugar, Q., Heinisch, D., Lundy, B. J., Witte, P., Wu, W., & Zhou, S. (2016, November 7). Estimating Ultimate Recovery and Economic Analysis of Shale Oil Wells in Eagle Ford and Bakken. Society of Petroleum Engineers. doi:10.2118/183396-MS.

The blanket bond phenomena

All states studied allow some form of "blanket bonds." They provide a fixed amount of coverage to secure P&A obligations for what is often an unlimited number of wells under a single operator. In other words, they don't scale with the liability, though some states require additional blanket bonds for a producer's idle or inactive wells. Blanket bonds reduce the effective bond amount per well for operators with larger well counts in the state. As a result, a large percentage of a state's overall orphan well liability risk can be concentrated in a small number of large operators. For example, according to Enverus data, the top 10 producers in the State of New Mexico own 42% of the unplugged wells in the State.

To understand how blanket bonds can result in disproportionate under-coverage of liabilities, take the example of Hilcorp Energy Corporation, a privately-held company. Hilcorp is the largest operator in New Mexico with over 11,500 unplugged wells. This amounts to over 15 percent of all unplugged wells in the state. We estimate the cost to plug these wells is $1.2 billion, which comes out to an average cost per well of just over $100,000.

Based upon New Mexico State data, the bulk of Hilcorp's wells are on federal lands overseen by the Bureau of Land Management (BLM), with additional wells on Indian lands (managed by the Bureau of Indian Affairs (BIA)), and then private and state lands overseen by the New Mexico Oil Conservation Division (NMOCD). Each regulatory body permits the use of blanket bonds. These regulators also have discretion to increase bonding amounts, but we have been unable to obtain any evidence that they have done so on Hilcorp's wells.

In the case of the federal agencies, a bond with $150,000 covers all wells nationwide. NMOCD's blanket bond for more than 100 wells is $250,000, but it requires additional bonding for wells in "temporarily abandoned" status — an additional $500,000 for less than 25 wells, or an additional $1 million for 25 or more. Based upon these legal requirements, and assuming that New Mexico could call the entirety of any nationwide bonds, Hilcorp could have up to $1.55 million in bonds to cover New Mexico liabilities — less than 0.2% of the $1.2 billion in liabilities we have estimated.

Estimated well closure costs

Table 1 below lists the number of unplugged wells in each state, the total cost to close those wells assuming a flat cost of $30,000 per well (estimates in this range are commonly reported by oil companies and data providers – Diversified Gas & Oil — $28,400 per well;[6] and Rystad — $20,000 to $40,000 per well[7], though in our view are far too low) and the total cost calculated by us (CTI) using the depth-based cost model described in Appendix A. These include all wells within the state's geographic boundaries, regardless of whether they are subject to state or federal regulation (i.e., the Bureau of Land Management and/or Bureau of Indian Affairs) and for purposes of this paper, we have combined liability and bonding estimates for state and federal level into single numbers for relevant states.

We believe our depth-based estimates, which exclude obligatory surface remediation and other potential closure costs, conservatively reflect industry's cost to complete well closure in the ordinary course of operations as wells become non-economic.

Appendix B contains additional closure cost details, based on well operating status, production type, and production volumes for each state covered in Table 1. This allows the reader to understand the extent to which a given state's inventory includes non-producing and marginal wells that might be considered the most at risk of becoming orphans.

Table 1. State orphan well liability risk — unplugged wells

State	# of Wells (000's)	Cost @ $30k/well ($B)	CTI Estimate ($B)
Texas	783	23	117
Oklahoma	288	9	31
Pennsylvania	174	5	15
Ohio	170	5	13
New Mexico	73	2	10
Louisiana	71	2	10
Wyoming	64	2	10
North Dakota	29	1	8
West Virginia	102	3	8
California	108	3	7
Colorado	60	2	7
Utah	27	1	5
Alaska	5	0	1
All Other	637	19	39
Total	**2,592**	**78**	**280**

[6] See 2019 Diversified Gas & Oil investor presentation at: https://d1io3yog0oux5.cloudfront.net/_28d9d5529099b5877b9e19aa9798c2da/dgoc/db/557/4323/pdf/DGO+-+Investor+Presentation+-+June+2019_vFinal_updated+slide+13.pdf
[7] https://www.rystadenergy.com/newsevents/news/press-releases/american-backyard-wells-the-flexible-11pct-of-the-us-onshore-oil-output-now-face-an-inflexible-choice/.

Wells on federal lands

The federal government is responsible for regulating oil and gas wells drilled on federal land and may end up paying to clean up orphaned wells when they stop producing. Orphaned wells on federal lands fall to the U.S. Bureau of Land Management (BLM) rather than the states to plug and reclaim. Table 4 lists the number of wells on federal lands as of 2018.[8] These figures do not include wells on Indian lands (with leases managed by the Bureau of Indian Affairs). The implication is that a material portion of the orphan well liability risk estimates for states like New Mexico and Wyoming in fact lies with the Federal Government.

Table 2. Number of Producible and Service Well Bores on Federal Lands

State	FY 2018
New Mexico	31,214
Wyoming	30,730
Utah	9,285
California	7,938
Colorado	7,272
North Dakota	2,701
Ohio	598
Texas	544
Oklahoma	489
Louisiana	455
West Virginia	285
Pennsylvania	216
Alaska	107
All other	4,365
TOTAL	**96,199**

[8] https://www.blm.gov/programs/energy-and minerals/oil-and-gas/oil-and-gas-statistics.

Bonds on federal wells

The U.S. Government Accountability Office (GAO) has recently concluded that bonding levels for wells on federal lands are low. Most wells administered by the federal government are covered by blanket bonds. For example, on Indian lands, operators supply a single bond for approximately $75,000 to cover all of the operators wells in a state, or $150,000 to cover all wells nationwide.[9] GAO notes that average bonds per well have decreased over the past decade, estimating that, in 2018, the average bond value per well for wells on federal lands is $2,122.[10]

Bond coverage by state

Most oil producing states do not make bond coverage data readily accessible, Colorado's online database being a notable exception.[11] We submitted Freedom of Information Act (FOIA) requests to several states and received bond data from a subset of them in time for publication, including the following: Colorado, Montana, New Mexico, North Dakota, Pennsylvania, Utah, West Virginia, and Wyoming (the "Bonding Data States").[12] We estimate the potential P&A liability for the Bonding Data States to be $64 billion, approximately 23% of the total U.S. onshore estimated liability.

The coverage ratios for Bonding Data States is shown in Table 3.[13]

[9] 25 CFR § 225.30.

[10] U.S. GAO, Oil and Gas: Bureau of Land Management Should Address Risks form Insufficient Bonds to Reclaim Wells, (Sept. 2019), at 11.

[11] https://cogcc.state.co.us/data5_ext.html#cogis

[12] We also received data from Kansas, Illinois, Louisiana and Mississippi. While some states such as Colorado make bonding data available online and others promptly responded to data requests, the following states did not provide data in response to FOIA requests in time for this publication: Alabama, Alaska, Arkansas, California, Michigan, Ohio, and Oklahoma. One state, Arkansas, provides freedom of information solely to state citizens. We note that Texas has indicated that the data can be found in its publicly available online repository.

[13] Table 3 includes estimates from GAO on per well bond coverage for BLM wells in each state whereas the state bonds reflect information on actual bonds from state databases.

Table 3. Bonding Coverage - Selected States

State	CTI Estimate ($B)	State Bonds ($B)	Federal Bonds ($B)	Total Bonds ($B)	Orphan Well Liability Risk ($B)	Bond Coverage Ratio
Colorado	7.09	0.16	0.02	0.18	6.92	2%
Montana	1.86	0.01	0.00	0.01	1.85	1%
New Mexico	10.31	0.10	0.07	0.17	10.14	2%
North Dakota	7.92	0.08	0.01	0.09	7.83	1%
Pennsylvania	14.58	0.05	0.00	0.05	14.53	0%
Utah	4.99	0.02	0.02	0.04	4.95	1%
West Virginia	7.66	0.03	0.00	0.03	7.63	0%
Wyoming	9.51	0.19	0.07	0.26	9.25	3%
TOTAL	**63.92**	**0.64**	**0.19**	**0.83**	**63.10**	**1%**

The results make clear that, on average, the bonds in place cover roughly 1% of expected P&A costs. But what if per well P&A costs were closer to $30,000 per well? Even in that case, existing bonds represent less than 6% of total estimated liability for the Bonding Data States.

This universally low bond coverage is a function of three key drivers: (a) underestimated P&A costs that fail to reflect the exponential correlation of costs with depth; (b) low single-well bond amounts relative to estimated costs; and (c) the prevailing use of blanket bonds.

The gap is likely too big to be closed via legislation, though such efforts exist. For example, the Moving Forward Act now working through the U.S. Congress proposed setting aside funds to pay for orphaned wells. But the sums proposed, approximately $2 billion over a five year period, cannot close the gap.[14] Indeed, a more likely solution embedded in the Moving Forward Act is the requirement that, in return for money to close wells, states must increase bonding levels to reflect actual costs of closure. Some operators can likely afford this, others cannot.

In the event of operator default, low coverage ratios mean either that: (a) states will be on the hook for substantial clean-up costs, or (b) they will have to live with the environmental risks of idle and unplugged wells including groundwater contamination, greenhouse gas and toxic air emissions, combustion risks, and degradation of land that adversely impacts surface owner land values and uses.

Inactive wells and blanket bonds

Inactive wells pose a particular problem since it is highly uncertain whether they will generate cash flows again. If operators become distressed, these wells run a high risk of being orphaned to the state. In response, some state statutes permit or require "excess" bonds for inactive wells, but even these additional bonding requirements do not come close to addressing the scale of the problem.

For example, Texas allows operators to delay closure of inactive wells in exchange for additional bonding.[15] Operators can defer closure indefinitely for an unlimited number of wells by providing a blanket bond in the amount of the Railroad Commission's estimated cost to plug all of the operator's inactive wells, or $2 million, whichever is less.

We collected inactive well data from the Railroad Commission's ("RRC") website for the 15 largest operators in Texas. Where we could determine the depth of the well, we calculated an estimate of the cost to plug and then compared this to the RRC's estimate. On average, our estimates for P&A costs exceeded the RRC's estimate by 267%. Both our estimates and the RRC's estimates exceeded $2 million for each operator.

[14] https://energynews.us/2020/06/23/national/support-grows-for-taxpayer-funded-oil-well-cleanup-as-an-economic-stimulus/
[15] https://www.rrc.state.tx.us/oil-gas/compliance-enforcement/hb2259hb3134-inactive-well-requirements/plugging-extension-requirements.

Table 4 below shows the relative bond coverage for each company. Note that the Table excludes wells for which depth data was not available. Thus, it does not reflect each company's full estimated liability for inactive wells.

Table 4. Texas idle well bond coverage by operator

Company	# of Wells	CTI Cost Estimate ($M)	Bond Amount ($M)	Bond Coverage
Apache Corporation	1,642	220	2	1%
BASA Resources	729	91	2	2%
Blackbeard Operating, LLC	1,584	243	2	1%
Chevron USA	619	146	2	1%
EOG Resources	349	67	2	3%
FDL Operating	952	161	2	1%
Hilcorp Energy	2,323	374	2	1%
Kinder Morgan	989	104	2	2%
Occidental Permian	1,658	249	2	1%
OXY USA	816	134	2	1%
Pioneer Natural Resources	490	105	2	2%
Sabinal Energy	419	69	2	3%
Scout Energy	1,827	251	2	1%
UPP Operating	884	145	2	1%
XTO	1,744	290	2	1%
TOTAL	**17,025**	**2,648**	**30**	**1%**

Thirty million dollars in total bond coverage for over 17,000 inactive wells amounts to less than $2,000 per well in bond coverage. Applied to the RRC's P&A cost estimates, that amounts to a mere 3% of closure costs. Factoring in our P&A estimates based on well depth, the situation is worse — a mere 1%. With bonding at these levels, companies have no financial incentive to ever incur the full costs of closure. In effect, this system provides these companies with an infinitely renewable option to leave wells idle at nearly zero cost.

Even where states require individual bonds for single-wells, that the amounts are usually insufficient. When wells in Colorado become inactive, the operator must supply an "excess" bond on a per well basis — $10,000 for wells less than 3,000 ft. deep, and $20,000 for wells deeper than 3,000 ft. By comparison, the Enverus data used in our model indicates that the average total vertical depth for a well in Colorado is 6,750 feet.[16] Our model yields an expected P&A cost of roughly $144,000 per well — more than seven times the highest inactive well bonding requirement.

While the "excess inactive" bonds are a critical component of Colorado's bonding regime, supplying approximately 79% ($126.5 million) of $160.3 million in total bond coverage for the state, the data above suggests that they are insufficient to meet closure requirements and this gap will only grow as the ranks of inactive wells swell. Based again on Enverus data, we count more than 4,900 wells in its database that have no oil or gas production in the last 24 months.[17] In our model, the total P&A cost estimate for this subset of wells is more than $657 million.

It is important to note that the inactive bond regime only applies to those wells that have ceased production. Therefore, it excludes the tens of thousands of stripper wells in Colorado which produce less than 15 boe/day and which we estimate will cost over $3.6 billion to plug. A question for Colorado, and other states, is whether some of the proceeds from stripper wells should be set aside to pay for their eventual retirement.

[16] CTI analysis, Enverus data. Excludes wells where no total vertical depth information is provided.
[17] It is unclear whether these (and other wells) are included in Colorado's excess inactive bonding program, and we have not sought to determine that.

What comes next?

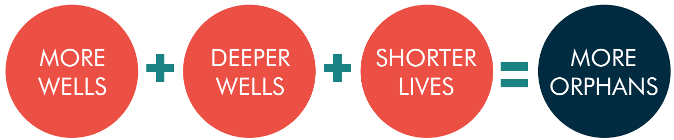
The timing of well closure is subject to production decline rates, current and forecasted future economic conditions, and state tolerance for indefinite "temporary abandonment" of inactive wells. The risk of operator default is subject to operator leverage with the regulator, current and future economic conditions and the willingness of regulators to approve the transfer of wells from larger to smaller companies. These factors are subject to significant uncertainty and estimating the timing of well closure and the risk of operator default is beyond the scope of this report.

However, it is clear that worsening economic conditions for the industry will bring forward retirement costs and may also scare off some prospective purchasers looking to acquire distressed assets on a discount. As the Petroshare bankruptcy illustrates, states are then confronted with unwanted wells that the debtor cannot afford to plug. At this late stage, it is possible that little can be done — save reduce the state's financial exposure going forward. That requires understanding which operating entities already can't afford to pay, i.e. are already environmentally insolvent given their existing liabilities.[18] States must also stop banking on future cash flow forecasts and start requiring financial assurance.

An unconventional problem

The foregoing characterizes the issues with the regulatory process as a whole, but there are reasons to believe that the inventory of deep, unconventional wells will present an even more complex problem. The characteristics of unconventional shale wells are different from conventional wells in ways that will both shorten their economic useful lives and increase closure costs, as seen in Figure 1:

Figure 1. The new math for shale wells



[18] https://www.nytimes.com/2020/07/12/climate/oil-fracking-bankruptcy-methane-executive-pay.html.

Shorter lives

The nature of unconventional drilling suggests that existing wells may struggle to perform a second act as stripper wells. Conventional oil and gas production involves the drilling of a well into a reservoir under natural pressure causing oil to flow out of the ground. Eventually, as the reservoir pressure drops, operators use pumpjacks to pump the remaining oil to the surface. These marginal wells may operate for decades as "stripper" wells. Operators may even run these low producing wells at a loss for years to defer closure.[19]

Unconventional oil and gas production involves vertical and horizontal drilling into tight shale formations, followed by high pressure fracturing of the formation to allow oil and gas to flow more quickly. Unconventional oil drilling is a more expensive process than conventional oil drilling, but it has advantages – the ability to drill lots of wells with virtually no chance of a dry hole and the ability to laterally reach more of a formation. However, when the oil and gas stops flowing naturally, which can happen much sooner than operators had initially forecasted, pumpjacks may be ineffective.[20]

More wells

A fracked well erupts with an initial burst of supply, followed by steeper production declines compared to conventional wells. Moreover, unconventional wells require additional ongoing expenditures to be re-fracked and to flatten the decline curve. This leads to a second problem — the need to frequently drill more wells in order to offset production declines, and the need to incur additional costs to maintain production at existing wells.[21] The result is a lot more wells that need to be eventually plugged and a greater risk that cash-poor companies will be unable to stimulate more production.

Deeper wells

As we explained in *It's Closing Time*, shale wells are much deeper than conventional wells and therefore more expensive to plug. Many states fail to account for depth in their bonding regimes at all, while others do so only as a rough approximation, or use linear cost functions which fail to capture the fact that cost per foot increases the deeper you go.

[19] https://www.rystadenergy.com/newsevents/news/press-releases/american-backyard-wells-the-flexible-11pct-of-the-us-onshore-oil-output-now-face-an-inflexible-choice.
[20] https://www.worldoil.com/news/2017/12/11/pumpjacks-fail-as-long-shale-wells-make-pumping-oil-harder.
[21] https://webcache.googleusercontent.com/search?q=cache:a88ndVcE8l8J:https://www.houstonchronicle.com/business/energy/article/Oil-s-Sudden-Rebound-Is-Exposing-the-15291883.php+&cd=25&hl=en&ct=clnk&gl=us.
[22] For more, see Three policy challenges — one solution. https://carbontracker.org/three-policy-challenges-one-solution/

The result: More orphans

As illustrated in Figure 1, the combination of more wells, greater depths, and shorter lifespans means shale drillers will incur higher P&A costs sooner. This unfavorable math increases the likelihood that operators will default, passing these liabilities on to governments who are equally unprepared for the new math of shale drilling.

Relative to conventional wells, we expect that the fracked wells will have shorter lives and cost more to close than is currently expected. In a system that underestimates the cost of plugging such wells, companies will be incentivized to postpone costs until there is no feasible means of paying, resulting in more orphans.

Conclusion

States created the moral hazard that incentivizes oil and gas companies to defer and evade well closure obligations. Now they are poised to inherit billions in oilfield cleanup liabilities. States can and must act now to protect their citizens and taxpayers from the rising tide of idle and orphan wells. By doing so, they can shift financial responsibility for oilfield cleanup costs to industry, where it belongs, and also position themselves to qualify for U.S. federal aid.

APPENDIX A – Methodology

This appendix describes our methodology for producing the state well closure cost estimates in Table 1.

Data sources

We collected state well data, including total well counts, well status, production type, production activity and depth, from Enverus. Enverus was founded in 1999 as Drillinginfo, and now describes itself as "the energy industry's leading data, insights, and software company." We did not attempt to comprehensively verify the accuracy or completeness of the Enverus data.

Methodology

We filtered well data by state, well status, and basin. We filtered by well status to remove plugged and undrilled wells that do not have an outstanding plugging obligation. This included wells classified as cancelled (wells where the permit was cancelled prior to any physical work), expired permit (wells where the latest permit has expired prior to any physical work), permitted (authorized wells yet to be drilled), and P&A (wells previously plugged and abandoned).

We also filtered wells by basin to exclude offshore wells in state waters in the Pacific Ocean and Gulf of Mexico. Accordingly, our estimates account for onshore wells only.

Because all oilfield wells, regardless of purpose, must be plugged and abandoned according to state law,[23] we included wells with all production type classifications, including oil, gas, oil and gas, coalbed methane, injection, disposal, dry hole, monitor, storage, unknown, and water. Our well counts are therefore higher than those reported by some state regulators that account only for wells drilled to produce hydrocarbons.

Our well counts include unplugged onshore wells of "unknown" production type. Nationally, Enverus reports 483,000 such wells. Many of these appear to have come from older databases, including the PennWells database, that in some cases pre-date State-level tracking of wells. The operating status is inactive or unknown for three-quarters of these wells. Almost all have location data, but only 20% have depth information. Only 39% have a reported operator, and we have not sought to determine whether the listed operators are existing entities.

[23] Texas Rule 3.16 (Log and Completion or Plugging Report), which defines "wells" subject to reporting and plugging requirements under Rule 3.14 as "A well drilled for any purpose related to exploration for or production or storage of oil or gas or geothermal resources, including a well drilled for injection of fluids to enhance hydrocarbon recovery, disposal of produced fluids, disposal of waste from exploration or production activity, or brine mining."

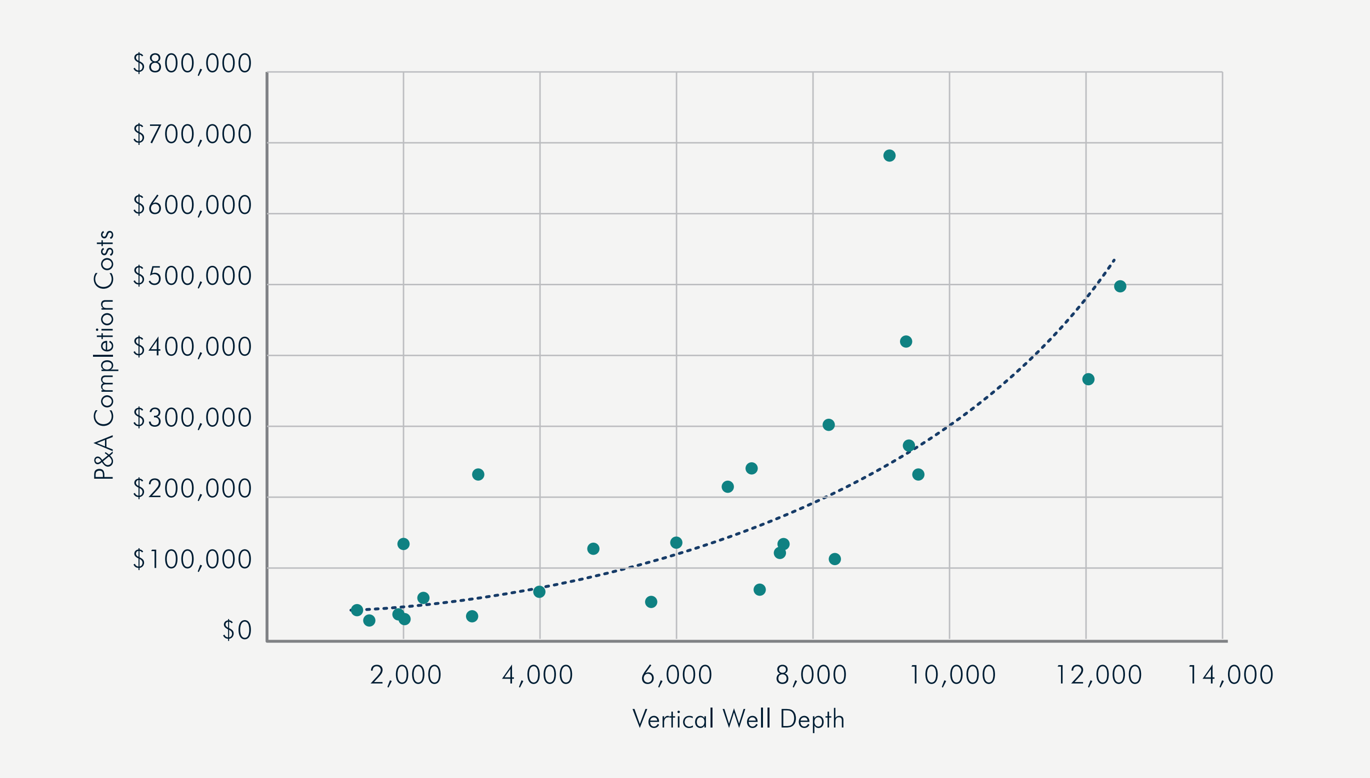
Although excluded from our well counts, Enverus lists 93,000 plugged wells of "unknown" production type, two-thirds of which are located in Oklahoma and West Virginia. We suspect but cannot confirm that these are legacy wells plugged by state orphan well programs.

We estimated total closure costs per state in two ways. First, we applied a flat cost of $30,000 per well. As reported in *It's Closing Time*, estimates in this range are commonly reported by oil companies and data providers: Diversified Gas & Oil — $28,400 per well;[24] and Rystad — $20,000 to $40,000 per well.[25] Such estimates are misguided because they fail to account for the fact that plugging costs, like drilling costs, increase with depth. However, this can be thought of as a "proxy" or baseline assessment of P&A costs by some in industry.

Second, we estimated closure costs based on True Vertical Depth (TVD), which Enverus defines as the "total true vertical depth of intended bottom hole measured in feet," using a depth-based exponential cost function. TVD is available for some wells and not for others. For onshore wells with a TVD measurement, we estimated the closure cost for each well by applying a depth-based cost function derived from the Australian P&A completion cost data described in *It's Closing Time,* and illustrated in Figure 2 below. Notwithstanding publicly available data showing that ultra-deep wells can cost over a million dollars to plug, we conservatively capped our per well cost estimates for such wells at the modeled cost to close a 10,000-foot well, approximately $300,000.

[24] 2019 Diversified Gas & Oil investor presentation at: https://d1io3yog0oux5.cloudfront.net/_28d9d5529099b5877b9e19aa9798c2da/dgoc/db/557/4323/pdf/DGO+-+Investor+Presentation+-+June+2019_vFinal_updated+slide+13.pdf
[25] https://www.rystadenergy.com/newsevents/news/press-releases/american-backyard-wells-the-flexible-11pct-of-the-us-onshore-oil-output-now-face-an-inflexible-choice.

Figure 2. Australian P&A completion costs by depth



We estimated the closure cost for onshore wells with no-TVD measurement based on the estimated cost (using the same cost model described above) to close a well having the average TVD of those wells within each state having a TVD measurement. For example, the average depth of onshore wells in California with TVD measurements is 2,800 feet. Our cost estimate for wells of this depth is $59,000, and we applied this cost to all onshore wells in California having no TVD measurement. This estimate is conservative when compared to the findings of a recent report from the California Council on Science and Technology (CCST), which estimated the cost to close onshore wells in the state at $68,000.[26]

Most wells listed with "unknown" production type lack well depth information. We suspect these are legacy wells that are likely to be shallower, on average, than newer wells. If this is the case, our cost estimates to plug these wells, based on the average depth of wells having depth data, may be overstated.

After calculating an estimated closure cost for each unplugged well, we summed the individual cost estimates to produce a total closure cost estimate for each oil producing state.

Limitations

Well counts

Enverus' unplugged onshore well counts may be significantly higher or lower than the figures listed on state databases. There are several reasons for this. Enverus collects a lot of its well data from the state and local governments that regulate the industry, but it also collects well data from other sources.[27]

Also, states may omit some well types from their published data. For example, the Railroad Commission of Texas reported a total of 439,695 oil and gas wells in the state, as of July 30, 2020.[28] By comparison, Enverus lists 444,000 wells classified as either "oil" or "gas". Enverus also lists 32,000 wells classified as "oil & gas", in addition to another 130,000 non-production wells (e.g., injection, disposal, and water wells), and 187,000 wells of unknown production type. In total, Enverus counts 783,000 unplugged wells in the Texas onshore oilfields.

In another example, Enverus counts 73,000 unplugged wells in New Mexico, whereas the State of New Mexico reports only 66,000 wells.[29] The difference appears to be 7,000 wells of unknown production type included in the Enverus database but excluded from the state's database. Almost all are inactive wells located in the San Juan basin.

[26] (See Finding 3-6: "Based on a small sample of well-level plugging costs, the statewide average cost to plug and abandon an onshore orphan well is $68,000."). https://ccst.us/wp-content/uploads/CCST-Orphan-Wells-in-California-An-Initial-Assessment.pdf.
[27] https://www.enverus.com/tag/oil-and-gas-data.
[28] https://www.rrc.state.tx.us/media/59240/wells-monitored-july-2020.pdf.
[29] https://wwwapps.emnrd.state.nm.us/ocd/ocdpermitting/Data/Wells.aspx.

Also, our well counts may vary from state well counts due to misclassification of well status (i.e., unplugged wells may be misclassified as plugged), data update cycles, or other reasons unknown to us.

Cost estimates

Our cost estimates are subject to significant estimation uncertainty. Actual well closure costs may be higher or lower.

Our cost estimates are based on industry P&A completion cost, data and therefore implicitly assume that oil and gas companies will fulfill their legal obligation to retire producing and idle wells in the ordinary course of operations. In the event that wells are orphaned, the cost to perform the same work by a state may be significantly lower due to greater timing flexibility, as shown in *It's Closing Time*. We have not considered whether that would remain the case if workover rigs for closures were in high demand, or other changes due to an uptick in plugging activity.

Our estimates, which are based on a P&A completion cost model, do not reflect the full range of potential costs to retire existing onshore wells and largely exclude well-specific factors other than depth, such as reclamation costs, well bore damage, and proximity to human populations and sensitive receptors. Reclamation costs can be high. For example, North Dakota reclaimed two orphaned sites in 2018 for a total cost of $862,338.[30] And the Director of the North Dakota Industrial Commission's Oil and Gas Division, Lynn Helms, estimates that they will incur reclamation costs at up to 40% of the sites they close.[31]

We do not include costs to decommission, plug and abandon offshore wells in state or federal waters.

We exclude adjustments for future inflation and the time value of money and do not consider state-specific well closure standards that could impact well closure costs.

We do not include all unplugged onshore oil and gas wells in the U.S. The U.S. Environmental Protection Agency (EPA) estimates that 1.15 million abandoned wells in the U.S. are not captured in the Enverus database.[32] Costs to close these wells are not included in our state cost estimates.

[30] https://www.nd.gov/auditor/sites/www/files/documents/Reports/State/2018%20Industrial%20Commission.pdf.
[31] Director, Lynn Helms, Oil and Gas Division, Department of Mineral Resources, North Dakota Industrial Commission. Oil and Gas Division Three-Part Education Series: Well Plugging and Reclamation, 2020. https://www.dmr.nd.gov/oilgas/pressreleases/Part_3_Reclamation.pdf
[32] https://www.epa.gov/sites/production/files/2018-04/documents/ghgemissions_abandoned_wells.pdf.

APPENDIX B – Well status detail

In this appendix we subdivide the state well count and closure cost totals Table 1 into five categories to provide a rough screen for orphan well liability risk. The five categories described in Table 5 are mutually exclusive and holistic in that they account for 100% of each state's reported wells.

Table 5. Orphan well liability risk categories

Category	Description
Producing	Unplugged wells with a Last Production (LP) date within the past two years and average daily oil and gas production equal to or greater than 15 barrels of oil or 90 Mcf of natural gas.
Stripper	Unplugged wells with a LP date within the past two years and average daily oil and gas production less than 15 barrels of oil or 90 Mcf of natural gas.
Injection + other	Unplugged injection wells and other unplugged wells with no reported oil and gas production, including wells classified as disposal, dry hole, monitor, observation, other, storage, and water.
TA (LP>24<60)	Unplugged temporarily abandoned (TA) wells with a LP date more than two years but less than five years ago.
Zombie (LP>60)	Unplugged wells with a LP date more than five years ago.

The following tables subdivide total orphan well liability risk for the states listed in Table 1 into the categories listed in Table 5.

State	Well Type	# of Wells	CTI Estimate ($M)	% of Total
Alaska				
	Producing	2,095	512	44%
	Stripper	299	70	6%
	Injection + other	1,773	421	36%
	TA (LP>24<60)	192	46	4%
	Zombie (LP>60)	435	105	9%
	TOTAL	**4,794**	**1,155**	**100%**
California				
	Producing	5,216	401	5%
	Stripper	19,435	1,398	19%
	Injection + other	66,833	4,284	58%
	TA (LP>24<60)	3,726	285	4%
	Zombie (LP>60)	12,599	1,034	14%
	TOTAL	**107,809**	**7,402**	**100%**
Colorado				
	Producing	13,316	1,371	19%
	Stripper	30,818	3,646	51%
	Injection + other	11,243	1,412	20%
	TA (LP>24<60)	2,984	442	6%
	Zombie (LP>60)	1,847	216	3%
	TOTAL	**60,208**	**7,087**	**100%**

State	Well Type	# of Wells	CTI Estimate ($M)	% of Total
Louisiana				
	Producing	6,006	1,513	15%
	Stripper	28,295	3,200	31%
	Injection + other	18,814	2,749	27%
	TA (LP>24<60)	4,185	638	6%
	Zombie (LP>60)	13,886	2,182	21%
	TOTAL	**71,186**	**10,282**	**100%**
New Mexico				
	Producing	12,043	1,974	19%
	Stripper	39,010	4,861	47%
	Injection + other	18,880	3,140	30%
	TA (LP>24<60)	1,258	143	1%
	Zombie (LP>60)	1,753	190	2%
	TOTAL	**72,944**	**10,309**	**100%**
North Dakota				
	Producing	10,326	2,985	38%
	Stripper	7,279	1,848	23%
	Injection + other	11,437	2,982	38%
	TA (LP>24<60)	108	29	0%
	Zombie (LP>60)	346	80	1%
	TOTAL	**29,496**	**7,924**	**100%**

Table continues overleaf

State	Well Type	# of Wells	CTI Estimate ($M)	% of Total
Ohio				
	Producing	2,533	555	4%
	Stripper	41,569	3,366	26%
	Injection + other	92,116	6,291	49%
	TA (LP>24<60)	6,474	474	4%
	Zombie (LP>60)	27,636	2,085	16%
	TOTAL	**170,328**	**12,771**	**100%**
Oklahoma				
	Producing	13,246	2,960	10%
	Stripper	63,810	8,502	27%
	Injection + other	158,923	14,588	47%
	TA (LP>24<60)	10,963	1,336	4%
	Zombie (LP>60)	41,207	3,646	12%
	TOTAL	**288,149**	**31,033**	**100%**
Pennsylvania				
	Producing	9,715	1,574	11%
	Stripper	73,948	5,254	36%
	Injection + other	70,855	6,515	45%
	TA (LP>24<60)	5,963	390	3%
	Zombie (LP>60)	13,205	844	6%
	TOTAL	**173,686**	**14,577**	**100%**

Table continues overleaf

State	Well Type	# of Wells	CTI Estimate ($M)	% of Total
Texas				
	Producing	63,670	14,514	12%
	Stripper	239,146	37,846	32%
	Injection + other	371,139	49,568	43%
	TA (LP>24<60)	26,133	3,877	3%
	Zombie (LP>60)	83,068	10,712	9%
	TOTAL	**783,156**	**116,517**	**100%**
Utah				
	Producing	3,098	673	13%
	Stripper	9,269	1,597	32%
	Injection + other	12,159	2,371	47%
	TA (LP>24<60)	826	129	3%
	Zombie (LP>60)	1,736	224	4%
	TOTAL	**27,088**	**4,994**	**100%**
West Virginia				
	Producing	3,026	461	6%
	Stripper	55,865	4,290	56%
	Injection + other	41,506	2,790	36%
	TA (LP>24<60)	1,082	76	1%
	Zombie (LP>60)	640	44	1%
	TOTAL	**102,119**	**7,661**	**100%**

Table continues overleaf

State	Well Type	# of Wells	CTI Estimate ($M)	% of Total
Wyoming				
	Producing	11,465	2,762	29%
	Stripper	20,575	2,887	30%
	Injection + other	20,644	3,141	33%
	TA (LP>24<60)	3,570	319	3%
	Zombie (LP>60)	7,476	396	4%
	TOTAL	**63,730**	**9,505**	**100%**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