IEAGHG Information Paper 2014-27; The Trouble with Abandoned Wells

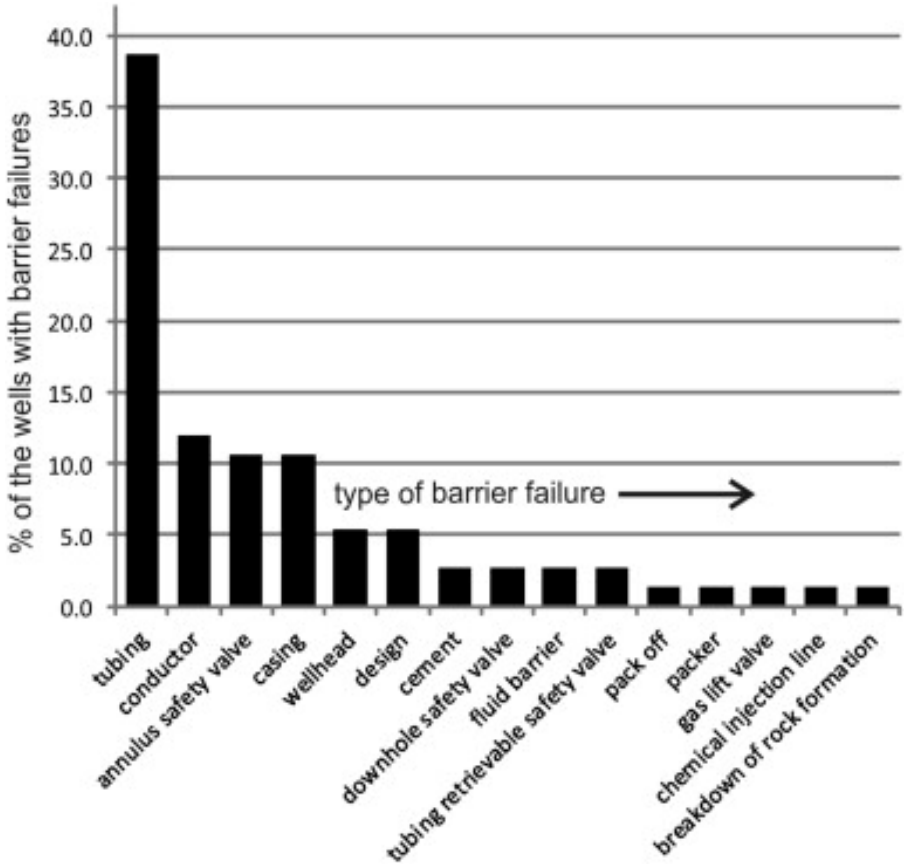
The aim of this information paper is to draw together recent pieces of research h work that have been published in 2014 on the issue of well integrity and methane release from abandoned wells. The paper then tries to draw parallels between these data sets and assesses the implication not just for methane release, but also for potential issues with CO_2 storage in the future.

The first a paper in Marine and Petroleum Geology entitled: Oil and gas wells and their integrity: Implications for shale and unconventional resource exploitation is a very comprehensive global study of well data. It was undertaken by a group of European scientists from an EU funded project called RefIne or Refining Fracking in Europe.

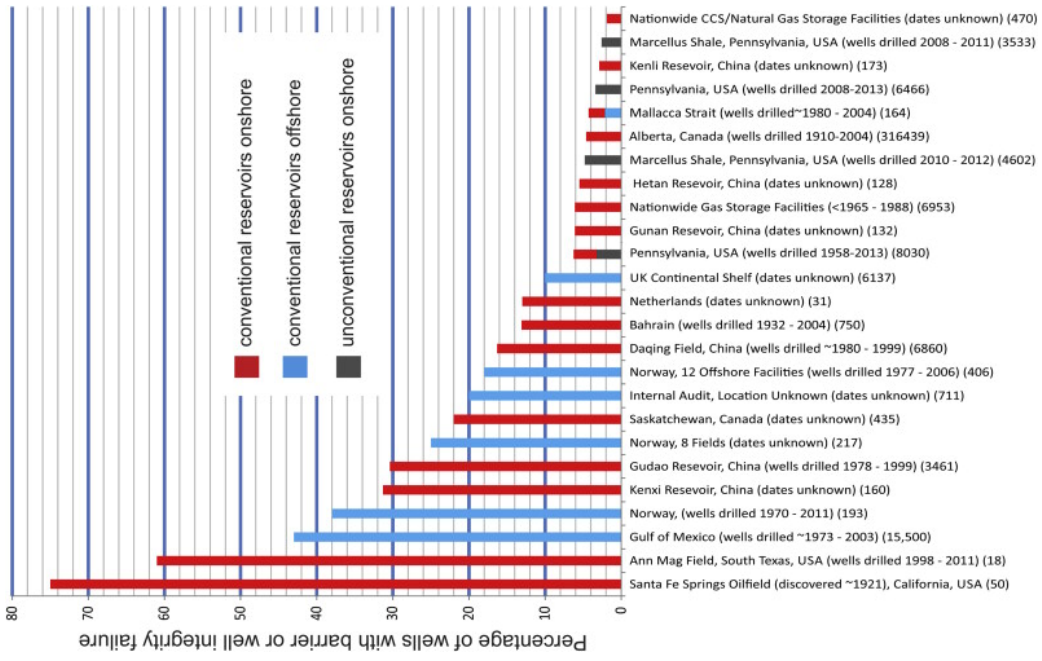
This comprehensive review of well data from around the world shows that more than four million onshore hydrocarbon wells have been drilled globally. The researchers have accessed all the reliable datasets (25) on well barrier and integrity failure in the published literature and online. These datasets include production, injection, idle and abandoned wells, both onshore and offshore, exploiting both conventional and unconventional reservoirs. The datasets vary considerably in terms of the number of wells examined, their age and their designs. Therefore the percentage of wells that have had some form of well barrier or integrity failure is highly variable (1.9%–75%). Of the 8030 wells targeting the Marcellus shale inspected in Pennsylvania between 2005 and 2013, 6.3% of these have been reported to the authorities for infringements related to well barrier or integrity failure. In a separate study of 3533 Pennsylvanian wells monitored between 2008 and 2011, there were 85 examples of cement or casing failures, 4 blowouts and 2 examples of gas venting. In the UK, 2152 hydrocarbon wells were drilled onshore between 1902 and 2013 mainly targeting conventional reservoirs. UK regulations, like those of other jurisdictions, include reclamation of the well site after well abandonment. Therefore there is no visible evidence of 65.2% of these well sites on the land surface today and monitoring is not carried out. The ownership of up to 53% of wells in the UK is unclear; it is estimated that between 50 and 100 are orphaned. Of 143 active UK wells that were producing at the end of 2000, one has evidence of a well integrity failure.

Some of the interesting statistics from this paper are given in the two figures on the next page;

Causes of barrier failures for the 75 (of 406) production and injection wells surveyed in offshore Norway that showed evidence for such failures



Graph of percentage of well barrier and integrity failures reported in 25 different studies around the world, with drilling dates and number of wells in each study.



The study which is of course focused on Europe concludes that It is likely that well barrier failure will occur in a small number of wells and this could in some instances lead to some form of environmental contamination. Furthermore, it is likely that, in the future, some wells in the UK and Europe will become orphaned. It is important therefore that the appropriate financial and monitoring processes are in place, particularly after well abandonment, so that legacy issues associated with the drilling of wells for shale gas and oil are minimised.

The second of the referenced studies was published in the US National Academy of Sciences, is entitled Assessment and risk analysis of casing and cement impairment in oil and gas wells in Pennsylvania, 2000–2012. The full paper for those interested can be found at: http://www.pnas.org/content/111/30/10955.short.

The report finds that casing and cement impairment in oil and gas wells can lead to methane migration into the atmosphere and/or into underground sources of drinking water. This result follows an analysis of 75,505 compliance reports for 41,381 conventional and unconventional oil and gas wells in Pennsylvania drilled from January 1, 2000–December 31, 2012. The analysis was performed with the objective of determining complete and accurate statistics of casing and cement impairment.

The report goes on to state that Statewide data show a sixfold higher incidence of cement and/or casing issues for shale gas wells relative to conventional wells. For post-2009 drilled wells, risk of a cement/casing impairment is 1.57-fold [95% confidence interval (CI) (1.45, 1.67); $P < 0.0001$] higher in an unconventional gas well relative to a conventional well drilled within the same time period. Temporal differences between well types were also observed and may reflect more thorough inspections and greater emphasis on finding well leaks, more detailed note taking in the available inspection reports, or real changes in rates of structural integrity loss due to rushed development or other unknown factors.

In the third of these studies Princeton University of the USA have also recently published a paper 8 in the Proceedings of the National Academy of Sciences, which describes how they chose 19 wells in the adjacent McKean and Potter counties in northwestern Pennsylvania. The wells chosen were all abandoned, and records about the origin of the wells and their conditions did not exist. Only one of the wells was on the state's list of abandoned wells. Some of the wells, which can look like a pipe emerging from the ground (see below), are located in forests and others in people's yards. A lack of documentation made it hard to tell when the wells were originally drilled or whether any attempt had been made to plug them.

A well pipe emerges from the ground in the Allegheny National Forest in northwestern Pennsylvania. Researchers covered pipes from 19 wells with instruments to measuring gases emitted by the well. (Photo courtesy of Mary Kang, Department of Civil and Environmental Engineering, Princeton University)

The researchers have used their results to extrapolate total methane emissions from abandoned wells in Pennsylvania, although they stress that the results are preliminary because of the relatively small sample. But based on that data, they estimate that emissions from abandoned wells represents as much as 10 percent of methane from human activities in Pennsylvania — about the same amount as caused by current oil and gas production. Also, unlike working wells, which have productive lifetimes of 10 to 15 years, abandoned wells can continue to leak methane for decades.

The researchers draw reference to a study by Stanford University in the USA which concluded that there were roughly 3 million abandoned wells in the United State. Therefore, because there are so many abandoned wells nationwide the researchers believe the overall contribution of leaking wells could be significant.

The paper in PNAS can be found at:

http://www.pnas.org/content/early/2014/12/04/1408315111.abstract

The researchers highlight the significance of these results in the paper as follows:

Recent studies indicate that greenhouse gas emission inventories are likely missing methane emission sources. We conducted the first methane emission measurements from abandoned oil and gas wells and found substantial emissions, particularly from high-emitting abandoned wells. These emissions are not currently considered in any emissions inventory. We scaled methane emissions from our direct

measurements of abandoned wells in Pennsylvania and calculate that they represent 4–7% of current total anthropogenic methane emissions in Pennsylvania. Millions of abandoned wells exist across the country and some are likely to be high emitters. Additional measurements of methane emissions from abandoned wells and their inclusion in greenhouse gas inventories will aid in developing and implementing appropriate greenhouse gas emission reduction strategies.

A more topical online version of the study can be found at:

http://www.princeton.edu/main/news/archive/S41/80/71G06/index.xml?section=topstories

Clearly there are several broad issues here:

1. There appear to be a lot of leaking wells in the USA the emissions of which are unaccounted in the national Inventory of greenhouse gas emissions. The emissions need to be characterised but more importantly mitigated.
2. There is also a major cross over to future CO_2 storage operations. If the USA is pock marked with abandoned wells then these will need to be isolated and sealed before CO2 storage in any such region on shore in the USA can take place.
3. It seems that there is a risk that wells will fail as either a result of tubing or cement failure, regulations for Drilling new CO2 wells might need to be reinforced to minimise this risk. Monitoring of abandoned wells also needs to be included in any CO2 storage regulations and a remediation plan also set out.

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23rd December 2014