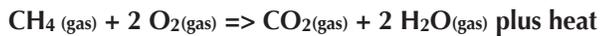


Natural Gas, Hydraulic Fracturing, and Water

There's more to the story than just pouring water down a (rat)hole

Hydraulic fracturing of rock to release natural gas uses a lot of water, right? It's common knowledge now that drilling a natural gas well and fracturing the rock uses about 5 million gallons of water, and the best estimates for how much stays in the well are about 80 percent. Do the math and you conclude that 4 million gallons of water end up thousands of feet below the surface for each well drilled.

But did you know that burning methane, by far the largest component in natural gas, creates water? It's true. Here's the chemical equation for the combustion of methane:



If you're having flashbacks to high school chemistry class, you're not alone. In words, the equation says that one molecule of methane (CH_4) reacts with two molecules of oxygen (O_2) to produce one molecule of carbon dioxide (CO_2) plus two water molecules (H_2O), plus a release of heat.

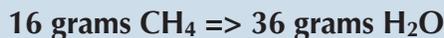
We don't often measure methane by the molecule preferring to refer to billions of cubic feet (bcf). So how much water (in gallons) do you get if you burn a billion cubic feet of methane? (If you aren't interested in more high school chemistry, skip the blue section and go right to the dramatic conclusion.)

Looking at just the methane and water in the equation, and ignoring the rest...



Multiply both sides of the partial equation by the molecular weight to change moles into grams.

The molecular weight of CH_4 is 16g/mole, H_2O is 18g/mole, so:



Now it's a simple conversion of units of measure. Let's convert grams of methane to cubic feet.

The density of CH_4 is .6556 grams per liter, so:



That's the left side.

Let's now convert grams of H₂O to gallons...

1 gal H₂O = 3785 grams, so:

36 grams (1 gal/3785grams) = .00951 gal.

That's the right side.

Our partial chemical reaction now looks like:

.862 ft³ methane => .00951 gal water.

Divide both sides by .862 and you get:

1 ft³ methane => .01103 gal water.

Multiply both sides by 1 billion and you get:

1 bcf methane => 11.03 million gallons of water.

Burning one billion cubic feet of methane produces just over eleven million gallons of water.

Earlier we said that estimates for the amount of water stranded underground were about 4 million gallons per well. If the well only produced 1bcf of natural gas, we would still produce almost three times as much water when we burned that gas as we trapped underground producing it. But, in fact, the average estimate of the amount of gas eventually recovered from a well is closer to 7bcf, meaning burning the methane from a single well puts 77 million gallons of water back into the atmosphere in the form of water vapor—almost twenty times the amount we used the frack the well.

77 million gallons of water is difficult to visualize, so we'll put it in terms we've used before: inches of rainfall. 5 million gallons of water is about 2.3 inches of rainfall over eighty acres. So 77 million gallons of water is 35.4 inches of rain over the same eighty acres. According to the website www.findthedata.org, that's only two inches less than the average annual rainfall in Pittsburgh over the last 30 years.

We're not the only ones to walk through the chemistry and come to this conclusion. Tom Shepstone wrote a similar article in April of 2012, which you can find at: <http://eidmarcellus.org/marcellus-shale/turning-natural-gas-into-water-hydraulic-fracturing-doesnt-deplete-water-supplies/7713/>

Our conclusion is that the argument that fracking consumes precious water supplies doesn't hold water.

As an aside, what if we viewed the water as the desirable output of a natural gas well, and the heat as a byproduct? From that perspective, a well that cost us \$5million to drill and frack produces a net 71 million gallons of water. The cost per gallon, (excluding the costs associated with condensing the water and transporting it), is about 7 cents—and the energy is free.



Muhlenkamp & Company, Inc.
5000 Stonewood Drive, Suite 300
Wexford, PA 15090
(877) 935-5520
www.muhlenkamp.com