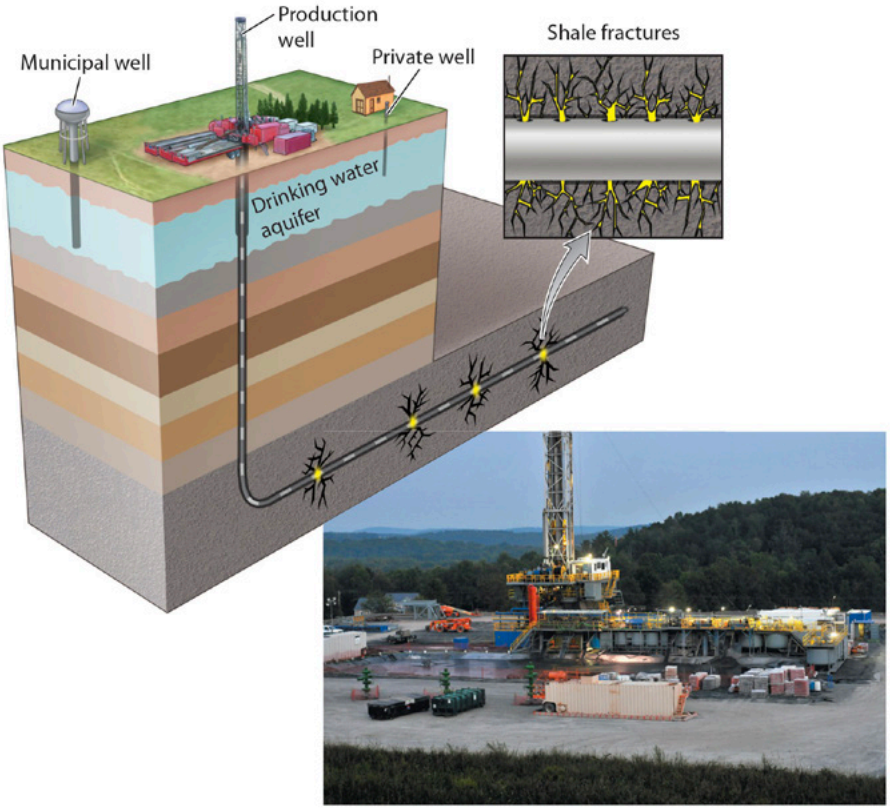
Chapter 17: Essay

Fracking for Shale Gas

We depend greatly on fossil fuels to meet our energy needs. Three major forms of fossil fuels are coal, petroleum, and natural gas. Both coal and petroleum are made of large and complicated carbon-based molecules. The main component of natural gas, by contrast, is methane, CH_4, which is a structurally simple molecule. Traditionally, coal and petroleum have been much more accessible in larger quantities than natural gas. A prime reason for this is because much of the world's natural gas remains trapped miles beneath the surface within a type of rock known as shale.

Two technological advances are now allowing access to this otherwise difficult to reach natural gas, also called *shale gas*. The first is our ability to drill very deep and then sideways. This is important because shale deposits are laid down horizontally. As shown in the accompanying image, drilling sideways maximizes the surface area of the shale within reach of the bore hole. The second advance is the process of *hydraulic fracturing*, also known as fracking, in which channels are punched into the shale using a powerful explosive. A slurry of water and sand with a small amount of other chemicals, such as anticorrosion agents and lubricants, is then injected into these channels. This slurry is known as *fracking fluid*. Under high pressure, this fluid expands into natural cracks, which remain open as grains of sand become lodged within them. After the fracking fluid is removed, large volumes of natural gas, which is lighter than air, escape through the cracks and rise to the surface, where the gas is piped to a storage facility for future use.

Millions of gallons of water are used to frack a single well—typically 5 to 15 million gallons, and as much as 400 million gallons for the largest wells. The used fracking fluid is toxic and requires special



Λ Figure A

Shale deposits are thousands of feet deep and usually only about 100 feet thick, so the most efficient access is provided by horizontal drilling. Natural cracks in the shale contain large amounts of natural gas. These cracks are forced open by high-pressure fracking fluid.

methods of disposal. Regulations for this disposal, however, vary from state to state. Some states permit local municipal water treatment facilities to accept fracking fluid. In states with more stringent regulations, wells may be drilled deep below the local water table. The used fracking fluid is then pumped to the bottom of these deep wells where it is pushed into the sub-water table ground.

There is currently a "gold rush" for shale gas, with thousands of new wells being drilled every year. Notably, by the year 2022, over 90 percent of the U.S. natural gas supply came from fracking operations. Two decades earlier this figure was only about 30 percent. Hundreds of thousands of jobs have since been created either directly or indirectly from this new industry. Furthermore, land owners are profiting from fees and royalties paid to them by companies who establish wells on their property. With fracking technology, the United States in 2009 surpassed Russia to become the world's leading producer of natural gas.

In addition to economic benefits, there are also potential environmental benefits to increased production of natural gas. As described in Chapter 17, most of the electricity produced in the United States comes from the burning of coal, which generates large amounts of pollutants, such as particulates, mercury, sulfur dioxides, and carbon dioxide. Natural gas, however, burns with much greater efficiency while generating far fewer pollutants—the output of carbon dioxide, for example, is about half that of coal. Although shale gas is not the ideal environmentally friendly fuel, its development is seen by many in the industry as a responsible way to supply our energy needs for decades while other more sustainable energy technologies, such as solar energy, are developed.

Fracking technology, however, also involves significant environmental risks. Foremost is the issue of dealing with the large volumes of used fracking fluid. This fluid is usually stored in pools adjacent to the well before being shipped by truck to a disposal site. At each of these stages there is the potential for an accidental spill of the fluid into the environment. Furthermore, if the upper portions of the well are not properly installed, the used fracking fluid coming up the well could potentially seep into the water table, ruining local water supplies. The toxins that could be released include not only cancer-causing agents within the fluid formula but also toxic materials coming directly from the shale, such as heavy metals and hydrocarbons, as well as unhealthy concentrations of radioactive radium-226.

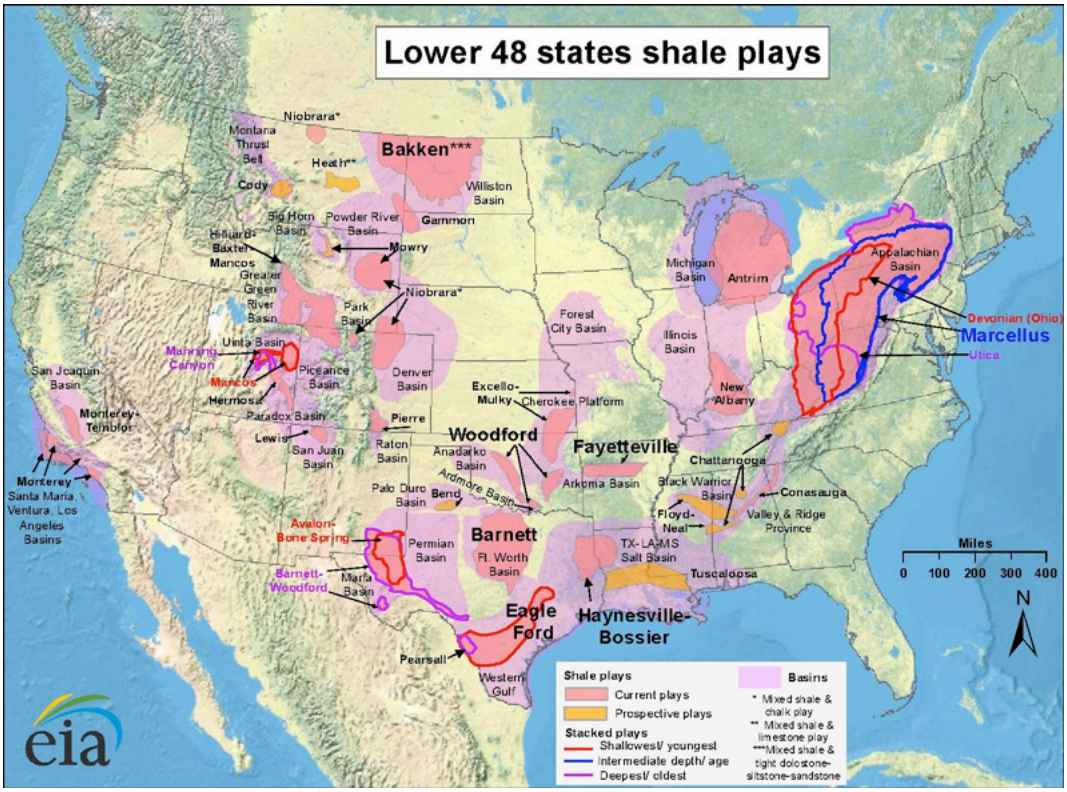


Figure B

Fracking technology was first developed in the Barnett shale on the property of the Dallas-Fort Worth International Airport. The richest gas-bearing shale in the United States is the Marcellus formation, centered over western Pennsylvania.

An added risk is gas leakage. Consider that as natural gas moves from the well to where it is used, about 2 to 6 percent of this gas leaks directly into the atmosphere. Methane itself is about 70 times more

potent a greenhouse gas than is carbon dioxide. Because methane reacts with oxygen, however, it resides in the atmosphere for only about 10 years before it is transformed into carbon dioxide. By some estimates, when well leakage is taken into account, the burning of shale gas for generating electricity actually contributes more to the global greenhouse effect than does the burning of coal.

In addition, there have been highly publicized instances in which people who live near a fracking well find methane in their water supply—so much that their water burns when lit with a match. The water supply in many areas naturally contains methane, which, though nonpoisonous, is highly combustible, so these instances may not be connected to fracking operations. In 2011, however, scientists at Duke University published a peer-reviewed study showing a strong correlation between flammable drinking water and distance from a fracking well. Although fracking occurs miles underground, this study suggests that the released methane may still reach the surface water table either by migrating up less than perfect well encasings or by migrating through geologic faults.

For people who live in areas of active drilling there are other concerns. A scenic rural area, for example, may be transformed into a zone of heavy industrial activity featuring tall drilling towers. Also, the truck traffic around an active drilling area is intense, causing damage to roads and creating much noise pollution that can at times run 24/7. Fracking for shale gas may benefit the nation as a whole, but that might not matter much to you if the fracking is happening right in your neighbor's backyard. There are strong social, economic, and political pressures for the continued exploitation of shale gas. There is also a general agreement that "best practices" need to be developed and enforced so as to safeguard against risks. The specifics of how to regulate this booming industry, however, are still being developed.

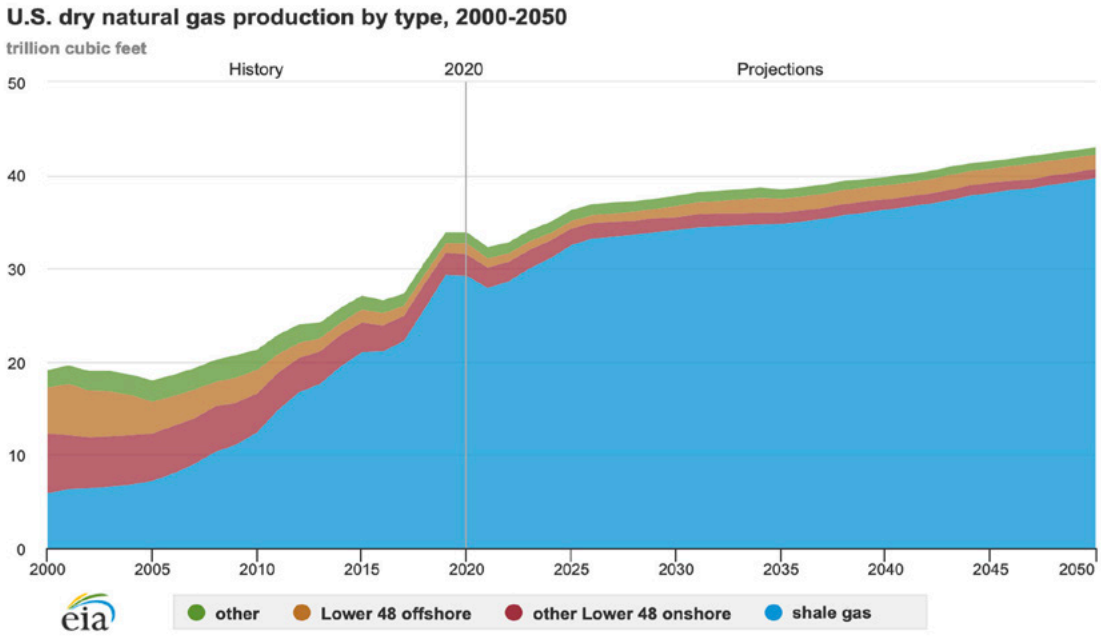


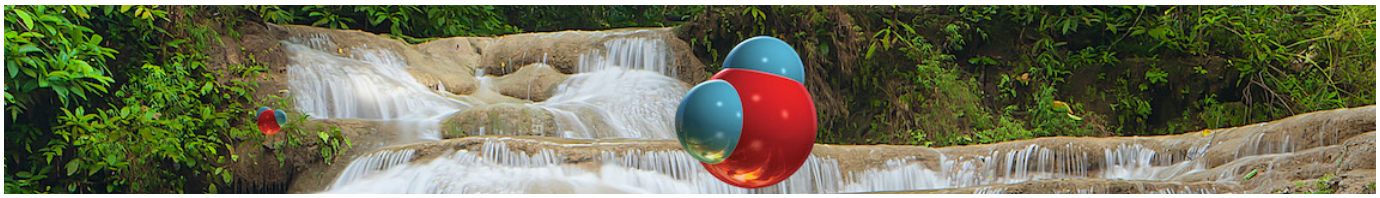
Figure C

Within the United States there has been an explosive growth in the production of shale gas over the past 10 years. Over the next 25 years, shale gas is projected to remain the major source of natural gas.

CONCEPT **CHECK**

What is the purpose of the sand within a fracturing fluid?

CHECK YOUR ANSWER The high pressure water opens up natural cracks within the shale. The sand gets stuck within these cracks, preventing them from reclosing. This allows gas seeping out of the shale to make its way to the bore hole.



Think and Discuss

1. Assuming a spacing of about 1 well for every 80 acres, it is estimated that the Marcellus shale of the northeastern United States alone could produce about 500 trillion cubic feet (ft^3) of natural gas over the next 50 years before being depleted. Currently, the United States consumes about 35 trillion ft^3 of natural gas each year. Assuming these rates are accurate and don't change, for how many years could the Marcellus shale meet the demand for natural gas in the United States?

2. The Safe Drinking Water Act of 1974 authorizes the EPA to regulate injection wells in order to protect underground sources of drinking water. In 2005, however, the U.S. Congress passed an amendment to this act that specifically exempts fracking operations from such regulations. Why do you suppose this amendment was approved? Why have attempts to repeal this amendment failed?

3. The 2005 amendment exempting fracking from the Safe Water Drinking Act had the effect of shifting fracking regulations from the federal government to individual states. Why might states be more effective at regulating fracking within their own borders? Why might the federal government actually be more effective?

4. Why should corporations of the fracking industry be encouraged to get together to spell out their own regulations? Should these corporations be trusted to enforce these self-imposed regulations?

5. The northeastern United States has large methane-bearing shale deposits buried deep underground. What other important resource is also available in the northeast that permits the extraction of methane from this shale?

Author Responses to Think and Discuss

1. About 14 years, which is 500 billion ft^3 divided by 35 billion ft^3 per year. After that, the boom could be over. Keep in mind that shale gas drilling is a heavy industry. This would involve the creation of about 400,000 wells. The impact on the land would be significant even in the absence of any environmental mishaps. Notably, the industry expects about 1 environmental mishap per 100 wells. Given 400,000 wells, that would correspond to about 4,000 environmental mishaps, such as fracking fluid spills, methane leakage, and blow outs. The reality of these environmental mishaps, and the reality that our consumption rate will increase, and the reality of the social, economic, and engineering difficulty of building a well for every 80 acres suggests that the Marcellus shale's potential may be less than 14 years.

2. In 2004, the EPA published a report indicating that hydraulic fracturing posed minimal threat to groundwater reservoirs used by humans primarily because these wells operate up to two miles below these reservoirs. The Congress at that time and even today is eager for the fracking industry to grow unhindered by unnecessary regulations. But one might wonder whether the Safe Drinking Water Act would have really been a hindrance to the industry if, after all, fracking for shale gas is truly of minimal threat to groundwater. Fracking for shale gas certainly offers huge benefits to the U.S., but protecting our fresh water resources should be of paramount importance.

3. Individual state environmental agencies are likely to be more familiar with the geology of their state and the specific needs and wishes of the people who live there. But they might also be even more sensitive to the needs of the corporations who bring economic prosperity to their state. Also to be considered: a hodgepodge of regulations from state to state, some more relaxed than others, complicates the implementation of best practices. For example, a fracking outfit operating close

to a state border might dispose of its used fracking fluid in the adjacent state permitting relaxed disposal methods. Rivers accepting fracking fluids within that state, however, might flow right back into the more restrictive state.

4. Fracking corporations have the technical know-how for what they do on a daily basis. Ideally, they learn from their mistakes and make necessary improvements to assure the safety of their operations. Ideally, they understand the importance of keeping fresh water resources clean and keeping good relations with the public they serve. Ideally, on-site managers will never cut corners on these regulations in order to squeeze out greater production levels. Ideally, accidents will never happen and if they do happen these accidents are reported. If a corporation claims that it intends to hold to its best practices in a stringent manner, then it should not be opposed to having an outside agency certifying that this actually happens.

5. Hydraulic fracturing requires large volumes of water, which is another resource readily found in the northeastern United States. Consider that southwestern Texas has large shale reserves, but with a poor water supply extracting this methane from this shale is not so feasible. Communities in the northeast need to be concerned not only with what happens to the used fracking fluid, but with making sure their fresh water supplies don't run low because of the volumes used by large scale fracking operations.