HYDRAULIC FRACTURING

(A SLIGHT APPROACH)

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Fracking (also hydrofracturing, hydrofracking, fracking, or fraccing) is shorthand for hydraulic fracturing, a type of drilling that has been used commercially for 65 years. Nowadays, the combination of advanced hydraulic fracturing, horizontal drilling, and cutting-edge technologies, is mostly responsible for surging U.S. oil and natural gas production, besides for the opening of a controversial debate about its possible environmental impact.

Hydraulic fracturing is highly controversial in many countries. Its proponents advocate the economic benefits of more extensively accessible hydrocarbons.[1] However, opponents argue that these are out-weighed by the potential environmental impacts, which include risks of ground and surface water contamination, air and noise pollution, and potentially triggering earthquakes, along with the consequential hazards to public health and the environment.

HISTORY

Hydraulic fracturing is not new. Fracturing as a method to stimulate shallow, hard rock oil wells dates back to the 1860s. Dynamite or nitroglycerin detonations were used to increase oil and natural gas production from petroleum bearing formations. On 25 April 1865, Civil War veteran Col. Edward A. L. Roberts received a patent for an "exploding torpedo".[2] It was employed in Pennsylvania, New York, Kentucky, and West Virginia using liquid and also, later, solidified nitroglycerin. Later still the same method was applied to water and gas wells. Stimulation of wells with acid, instead of explosive fluids, was introduced in the 1930s. Due to acid etching, fractures would not close completely resulting in further productivity increase.

The first commercial application of hydraulic fracturing as a well treatment technology designed to stimulate the production of oil or gas likely occurred in either the Hugoton field of Kansas in 1946 or near Duncan Oklahoma in 1949. In the ensuing sixty plus years, the use of hydraulic fracturing has developed into a routine technology that is frequently used in the completion of gas wells, particularly those involved in what's called "unconventional production," such as production from so-called "tight shale" reservoirs. The process has been used on over 1 million producing wells. As the technology continues to develop and improve, operators now fracture as many as 35,000 wells of all types (vertical and horizontal, oil and natural gas) each year. [3]

As of 2013, massive hydraulic fracturing is being applied on a commercial scale to shales in the United States, Canada, and China. Several additional countries are planning to use hydraulic fracturing.[4]

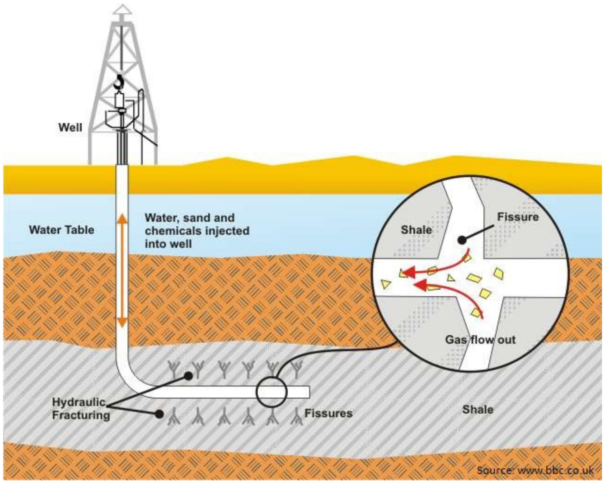
Hydraulic fracturing has had an enormous impact on America's energy history, particularly in recent times. The ability to produce more oil and natural gas from older wells and to develop new production once thought impossible has made the process valuable for US domestic energy production. Without hydraulic fracturing, as much as 80 percent of unconventional production from such formations as gas shales would be, on a practical basis, impossible.

THE PROCESS

According to the United States Environmental Protection Agency (EPA), hydraulic fracturing is a process to stimulate a natural gas, oil, or geothermal well to maximize extraction. The EPA defines the broader process that includes the acquisition of source water, well construction, well stimulation, and waste disposal. [5]

Method

A hydraulic fracture is formed by pumping fracturing fluid into a wellbore at a rate sufficient to increase pressure at the target depth (determined by the location of the well casing perforations), to exceed that of the fracture gradient (pressure gradient) of the rock. [6] The fracture gradient is defined as pressure increase per unit of depth relative to density, and is usually measured in pounds per square inch, per square foot, or bars. The rock cracks, and the fracture fluid permeates the rock extending the crack further, and further, and so on. Fractures are localized as pressure drops off with the rate of frictional loss, which is relevant to the distance from the well. Operators typically try to maintain "fracture width", or slow its decline following treatment, by introducing a proppant into the injected fluid– a material such as grains of sand, ceramic, or other particulate, thus preventing the fractures from closing when injection is stopped and pressure removed. Consideration of proppant strength and prevention of proppant failure becomes more important at greater depths where pressure and stresses on fractures are higher. The propped fracture is permeable enough to allow the flow of gas, oil, salt water and hydraulic fracturing fluids to the well.



Well types

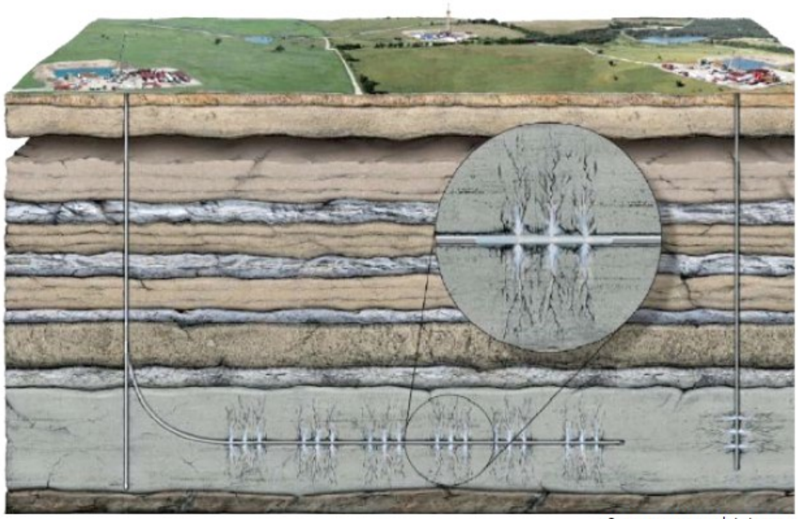
A distinction can be made between conventional, low-volume hydraulic fracturing, used to stimulate high-permeability reservoirs for a single well, and unconventional, high-volume hydraulic fracturing, used in the completion of tight gas and shale gas wells. High-volume hydraulic fracturing usually requires higher pressures than low-volume fracturing; the higher pressures are needed to push out larger volumes of fluid and proppant that extend farther from the borehole. [7]

Drilling often plugs up the pore spaces at the wellbore wall, reducing permeability at and near the wellbore. This reduces flow into the borehole from the surrounding rock formation, and partially seals off the borehole from the surrounding rock. Low-volume hydraulic fracturing can be used to restore permeability. [8]

Horizontal completions

Since the early 2000s, advances in drilling and completion technology have made horizontal wellbores much more economical. Horizontal wellbores allow far greater exposure to a formation than conventional vertical wellbores.

This is particularly useful in shale formations which do not have sufficient permeability to produce economically with a vertical well. [9]



Source: www.redstate.com

Fracturing fluid

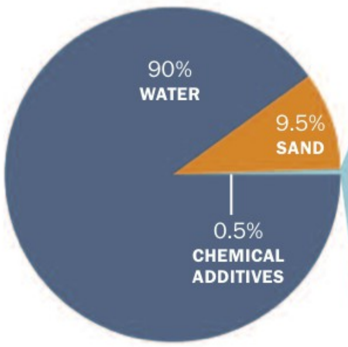
The main purposes of fracturing fluid are to add lubrication, change gel strength, carry proppant into the formation and extend fractures.

Fluid is typically a slurry of water, proppant, and chemical additives. [10] Additionally, gels, foams, and compressed gases, including nitrogen, carbon dioxide and air can be injected. Typically, 90% of the fluid is water and 9.5% is sand with chemical additives accounting to about 0.5%.[11] However, fracturing fluids have been developed using liquefied petroleum gas (LPG) and propane in which water is unnecessary.

The proppant is a granular material that prevents the created fractures from closing after the fracturing treatment. Types of proppant include silica sand, resin-coated sand, bauxite, and man-made ceramics. The choice of proppant depends on the type of permeability or grain strength needed. In some formations, where the pressure is great enough to crush grains of natural silica sand, higher-strength proppants such as bauxite or ceramics may be used. The most commonly used proppant is silica sand, though proppants of uniform size and shape, such as a ceramic proppant, are believed to be more effective.

Source: www.iasonmunster.com

Water is mixed with sand and chemicals to create fracking fluid. The number of chemical additives used in a typical fracture treatment depends on the conditions of the specific well being fractured. A typical fracture treatment will use very low concentrations of between 3 and 12 additive chemicals [12], depending on the characteristics of the water and the shale formation being fractured. Each component serves a specific, engineered purpose. For example, the predominant fluids currently being used for fracture treatments in the gas shale plays are water-based fracturing fluids mixed with friction-reducing additives (called slickwater). The addition of friction reducers allows fracturing fluids and sand, or other solid materials called proppants, to be pumped to the target zone at a higher rate and reduced pressure than if water alone were used. In addition to friction reducers, other additives include: biocides to prevent microorganism growth and to reduce biofouling of the fractures; oxygen scavengers and other stabilizers to prevent corrosion of metal pipes; and acids that are used to remove drilling mud damage within the near-wellbore area.



Compound	Purpose	Common application
Acids	Helps dissolve minerals and initiate fissure in rock (pre-fracture)	Swimming pool cleaner
Sodium Chloride	Allows a delayed breakdown of the gel polymer chains	Table salt
Polyacrylamide	Minimizes the friction between fluid and pipe	Water treatment, soil conditioner
Ethylene Glycol	Prevents scale deposits in the pipe	Automotive anti-freeze, deicing agent, household cleaners
Borate Salts	Maintains fluid viscosity as temperature increases	Laundry detergent, hand soap, cosmetics
Sodium/Potassium Carbonate	Maintains effectiveness of other components, such as crosslinkers	Washing soda, detergent, soap, water softener, glass, ceramics
Glutaraldehyde	Eliminates bacteria in the water	Disinfectant, sterilization of medical and dental equipment
Guar Gum	Thickens the water to suspend the sand	Thickener in cosmetics, baked goods, ice cream, toothpaste, sauces
Citric Acid	Prevents precipitation of metal oxides	Food additive; food and beverages; lemon juice
Isopropanol	Used to increase the viscosity of the fracture fluid	Glass cleaner, antiperspirant, hair coloring

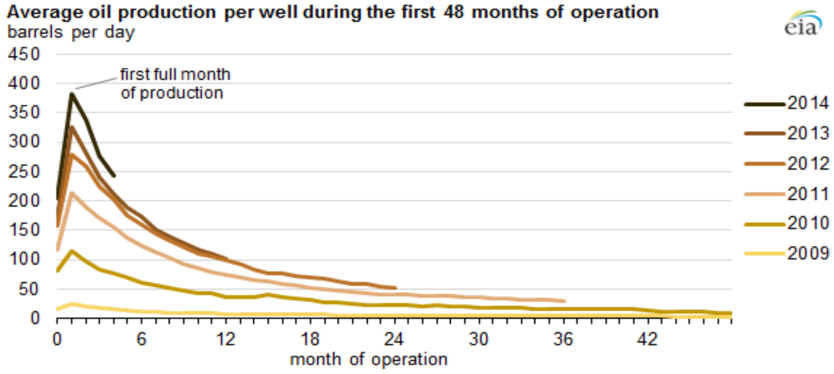
Source: DOE, GWPC: Modern Gas Shale Development in the United States: A Primer (2009).

SCOPE OF ACTION

Hydraulic fracturing is used to increase the rate at which fluids, such as petroleum, water, or natural gas can be recovered from subterranean natural reservoirs. Reservoirs are typically porous sandstones, limestones or dolomite rocks. But also include "unconventional reservoirs", such as shale rock or coal beds.

Hydraulic fracturing enables the extraction of natural gas and oil from rock formations deep below the earth's surface (generally 2,000–6,000 m), which is greatly below typical groundwater reservoir levels. At such depth, there may be insufficient permeability or reservoir pressure to allow natural gas and oil to flow from the rock into the wellbore at high economic return. Thus, creating conductive fractures in the rock is fundamental in extraction from naturally impermeable shale reservoirs.

The yield for typical shale bores generally falls off after the first year or two, but the producing life of a well can be extended up to several decades. [13]



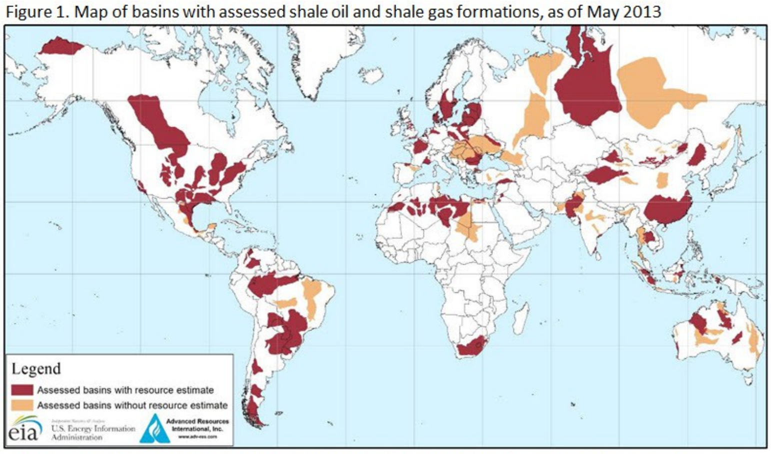
While the main industrial use of hydraulic fracturing is in stimulating production from oil and gas wells, hydraulic fracturing is also applied:

- To stimulate groundwater wells. [14]
- To precondition or induce rock cave-ins mining. [15]
- As a means of enhancing waste remediation, usually hydrocarbon waste or spills. [16]
- To dispose waste by injection deep into rock. [17]
- To measure stress in the Earth. [18]
- For electricity generation in enhanced geothermal systems. [19]
- Since the late 1970s, hydraulic fracturing has been used, in some cases, to increase the yield of drinking water from wells in a number of countries, including the US, Australia, and South Africa. [20]

BENEFITS OF FRACKING

According to the US International Energy Agency, the remaining technically recoverable resources of shale gas are estimated to amount to 208,000 km3, tight gas to 76,000 km3, and coalbed methane to 47,000 km3. Although there are also other methods to extract these resources, hydraulic fracturing is one of the key methods making their extraction economically viable. The multi-stage fracturing technique has facilitated the development of shale gas and light tight oil production in the United States and is believed to do so in the other countries with unconventional hydrocarbon resources.

Figure 1. Map of basins with assessed shale oil and shale gas formations, as of May 2013



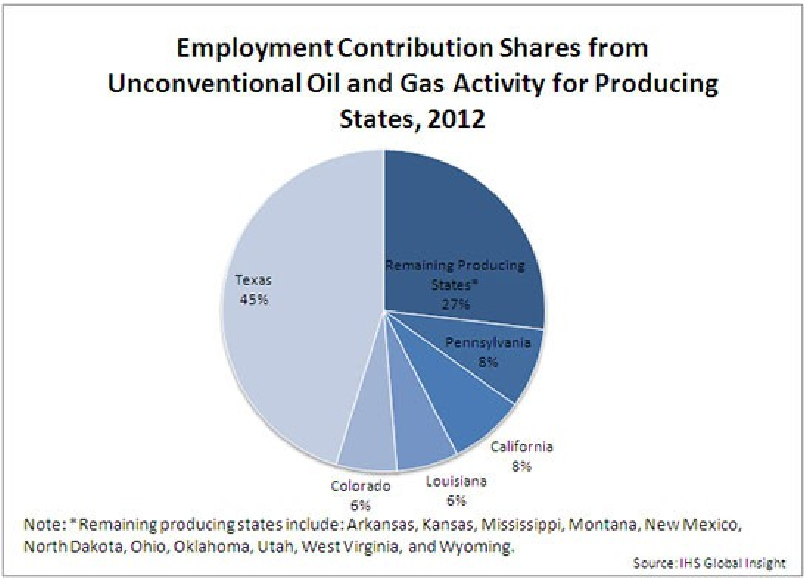
Source: United States basins from U.S. Energy Information Administration and United States Geological Survey; other basins from ARI based on data from various published studies.

The National Petroleum Council estimates that hydraulic fracturing will eventually account for nearly 70% of natural gas development in North America.[21]

Hydraulic fracturing and horizontal drilling apply the latest technologies and make it commercially viable to recover shale gas and oil. In the United States, 45% of domestic natural gas production and 17% of oil production would be lost within 5 years without usage of hydraulic fracturing.

Hydrofracked shale oil and gas has the potential to alter the geography of energy production in the US. In the short run, in counties with hydrofracturing, employment in the oil and gas sector has more than doubled in the last 10 years, with spill-overs in local transport, construction but also manufacturing sectors, that benefit from lower energy prices, giving them a competitive edge.[22]

On average, natural gas prices have decreased by more than 30% in counties above shale deposits compared to the rest of the US.



CONTROVERSY

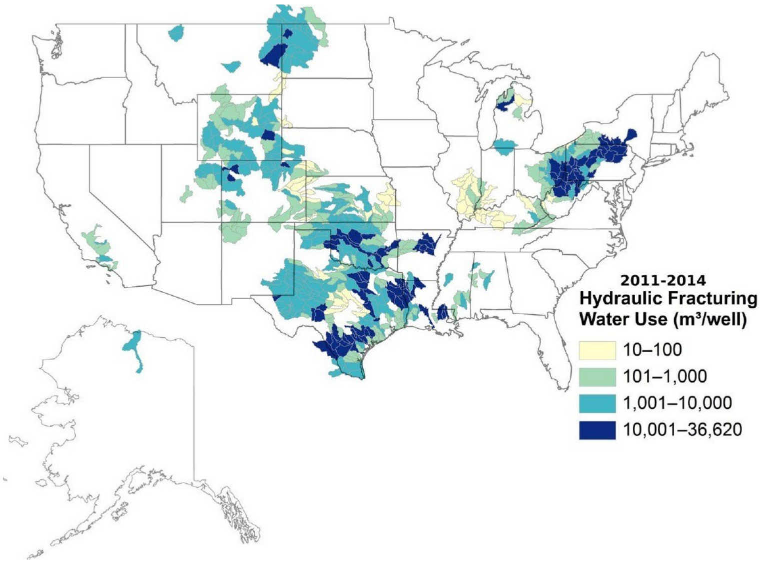
Economic effects

A study released in the beginning of 2014 concluded that, on the long-term as well as on the short-run, the "shale gas revolution" due to hydraulic fracturing in the United States has had very little impact on economic growth and competitiveness.[22] The same report concludes that in Europe, using hydraulic fracturing would have very little advantage in terms of competitiveness and energy security. Indeed, for the period 2030-2035, shale gas is estimated to cover 3 to 10% of EU projected energy demand, which is not enough to have a significant impact on energetic independence.

Environmental impact

An average well requires 10,000 to 30,000 m3 of water over its lifetime. According to the Oxford Institute for Energy Studies, greater volumes of fracturing fluids are required in Europe, where the shale depths average 1.5 times greater than in the U.S.[23]

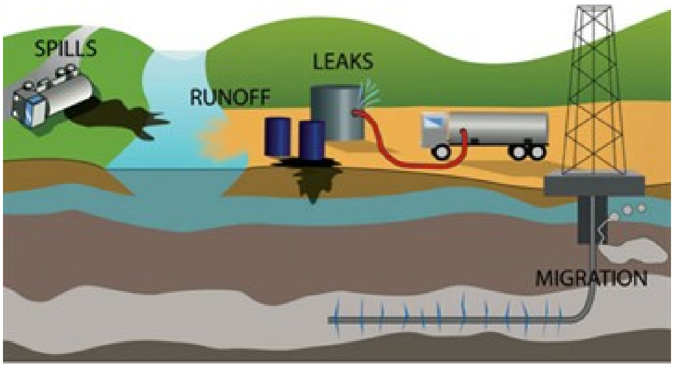
Typically less than half of the produced water used to fracture the formation is recovered. Produced water is managed by underground injection, municipal and commercial wastewater treatment and discharge, self-contained systems at well sites or fields, and recycling to fracture future wells.[24]



Surface water may be contaminated through improperly built and maintained waste pits and ground water can be contaminated if the fluid is able to escape the formation being fractured. [25]

Hydraulic fracturing sometimes causes induced seismicity or earthquakes. The magnitude of these events is usually too small to be detected at the surface, although tremors attributed to fluid injection into disposal wells have been large enough to have often been felt by people, and to have caused property damage and possibly injuries. [26]

For these reasons, hydraulic fracturing is under international scrutiny, restricted in some countries, and banned altogether in others.Some countries have banned the practice or put moratoria in place, while others have adopted an approach involving tight regulation. The European Union is drafting regulations that would permit controlled application of hydraulic fracturing.



(Riha & Rahm, Framework for Addressing Water Resource Impacts from Shale Gas Drilling (2010))

Typically the funding source of the research studies is a focal point of controversy.[27] Concerns have been raised about research funded by foundations, corporations, or by environmental groups, which can at times lead to at least the appearance of unreliable studies. Several organizations, researchers, and media outlets have reported difficulty in conducting and reporting the results of studies on hydraulic fracturing due to, and expressed industry and governmental pressure concern over possible censoring of environmental reports. There is a need for more research into the environmental and health effects of the technique.[28]

Scientists are predicting a renewable energy industrial revolution as technology brings new ways of thinking. Electric cars will transport energy as well as people across the city. Sunlight will be captured and transported across the world. Although hydraulic fracturing techniques had success not only in an economic but also in an environmental way, dependency on fossil fuels would be extended. It is a task of our society to decide on which way do we want to direct this 21st century energy revolution, perhaps the most important one for the world.

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