Hydraulic Fracturing:
Environmentally Friendly Practices

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Abstract

With the demand for energy on the rise, new techniques are being used to exploit the oil and natural gas at economic rates. One of the most common is hydraulic fracturing. This process, however, has environmental concerns that come with it, including chemical use, high fresh water use, air emissions, and surface area used. We have identified good management practices available that make hydraulic fracturing more environmentally friendly, while also being economical and efficient in time. These practices include replacing harmful chemicals, refracturing wells, closed loop drilling and fracturing, pad drilling, and centralized remote fracturing.

Introduction

Growing environmental concerns have come about the same time as increased energy demands. Along with the expanding need for domestic energy production, the United States has an expanding need to obtain our resources in a safe and effective manner. One energy source that is abundant in the U.S. is natural gas, an environmentally friendly alternative to coal, the United States' largest source of energy. Electrical power plants run by natural gas are much cleaner and more efficient than coal, while future estimates predict natural gas to soon be the most consumed form of energy (Harrison 2006). However, natural gas is a resource that is only commercially available with the advances of modern technology, particularly in horizontal drilling and hydraulic fracturing (Arthur 2009). Hydraulic fracturing is a process in which water, sand, and chemicals are pumped at high volumes and high pressures downhole to fracture tight oil and gas formations. If done properly, this process gives us the ability to safely meet our urgent energy needs.

Although studies have been done that show that hydraulic fracturing does not present an unreasonable risk to groundwater, environmental and public concerns related to this process have come to light (Jordan 2010). Some of the environmental issues concerning the public are the high water usage to fracture the formations, the air emissions put out by the increased truck traffic, the potential for groundwater contamination due to chemicals in the fracturing fluid, and the amount of space that a drilling pad site takes up on the surface.

One major problem that arises is the volume of water used in fracturing treatments. Fracture treatments in horizontal wells use 3 to 8 million gallons of fresh water on average (Chong 2010). Only 25 to 40% of this water is typically recovered in the first 90 days, which is when most of the flowback is recovered (Acharya 2011). Even the water that is recovered is costly to treat back to fresh water standards (Pierce 2010).

In order to use these high volumes of water, trucks have to transport it along with chemicals and sand to and from the sites during fracture treatments. With the volume of water that is typically used in these fracture treatments, the number of trucks necessary that travel to and from these sites can be very high. One estimate says that for 25,000 barrels of water (slightly over 1 million gallons), about 227 trucks would be necessary to transport the water (Horn 2009). The volume of trucks necessary, even for a smaller treatment, can put off air emissions at very high volumes, especially particulate matter emissions (Bar-Ilan 2011).

The chemicals in the fracturing fluid and the potential harm on drinking water they present are the environmental issue that has raised public awareness to the practice of hydraulic fracturing. Although no traces of chemicals from fracture fluid have shown up in water wells or in groundwater, the harm these chemicals could have is cause for public concern (Jordan 2010).

The amount of space required and cleared out for drilling rigs, although relatively small compared to the area accessed underground, roughly 6 acres on land compared to 32,170 acres under the surface, can be very expansive on land (Oluwaseun 2008). This area is often in farmland or forests, where it can have, and has had, an impact on the nature and landscape around it.

Due to these environmental concerns, the oil and gas industry is constantly under the eye of public scrutiny. Political ideologies and public perception shape environmental protection which affects the cost of production. However, environmentally friendly practices can be used that are also efficient in time and money compared to conventional practices. This paper will discuss five good management practices and the benefits of each environmentally, economically, and in efficiency.

Good Management Practices

Good management practices are practices used in the oil and gas industry that are considered the most effective, while still being environmentally friendly, economically efficient, and timely. This section will describe five good management practices, focusing on the environmentally friendly aspects of each. The five practices are removing harmful chemicals from fracturing fluid, refracturing wells, closed-loop drilling and fracturing, multiwell pad drilling, and centralized fracturing. Each of the five practices makes the drilling and fracturing process environmentally friendly, while often increasing the economic and time efficiency of those processes.

Replacing Harmful Chemicals

One of the public concerns about hydraulic fracturing is the use of chemicals in the fracturing fluid. Although the industry makes clear that these chemicals are found in household items, the general public does not know much about the chemicals or how hazardous they can be (Chesapeake 2011). Some of this has been helped by a website, www.FracFocus.org (GWPC and IOGCC 2011), which has reported chemicals and their amounts used in each well reported to the website. This is a step in disclosure, but does not change how harmful the chemicals actually are.

Currently, 75% or more of well site materials have proven to not be harmful to the environment (Rae 2001). One of the ways this was achieved was by progressive steps towards creating new chemicals that have the desired properties without being as harmful. It is very important that, even if the solution is not perfect, incremental steps are taken towards being more environmentally friendly. Every step in the right direction makes a difference in the end. Although this can be a long, expensive process to get to environmentally friendly chemicals and materials, it is important to do because in the long run, every step counts (Rae 2001).

That said, for success to be attained, a group effort from all exploration and production companies is necessary. This issue likely has multiple effective solutions, but it will take a collaborative effort to find the best solution. This push also needs the assistance of the environmental groups and regulators. This group, across the globe, needs to work with the industry and attempt to find a common ground across the board for regulations concerning how to be environmentally friendly concerning chemicals used (Rae 2001).

One effort in this direction is the Globally Harmonized System of Classification and Labelling of Chemicals (GHS). This system gives a universal identification process for all chemicals across the globe. This will allow for the handling and understanding of chemicals to be increased because, worldwide, there will be a single system to measure how hazardous a chemical is (Jordan 2010).

One company that has taken great strides toward this goal is Chesapeake Energy. Chesapeake's "Green Frac" Program, which was launched in October 2009, has a very clear goal: to become more environmentally friendly with hydraulic fracturing. In their testing, they are identifying any additives that are unnecessary and eliminating them. Their goal is to replace as many harmful additives as possible with environmentally friendly additives that serve the same purpose. These steps taken by Chesapeake are leading the industry, eliminating 25% of the additives used in normal fracturing processes with less harmful additives. They have also replaced many more with more environmentally friendly alternatives (Chesapeake 2011).

Refracturing

One of the problems faced in production in many wells, especially older wells, is that production generally decreases with time, making each day less economical to produce that well. Although drilling another well in a similar location is an option, a good management practice that can be used is refracturing the well. Refracturing can take different forms, such as enhancing the original fracture or creating new fractures (Vincent 2011).

In the Greater Green River Basin, great success was found using refracturing. In a study from 2006, which covers four different refracturing treatments, all of the wells significantly increased not only the initial production, but also the long term production. For the first well, Well A, the daily production average over the first 8 months was recorded as 161 Mscfd, compared to 355 Mscfd after the treatment. Comparing the first 8 months, the production more than doubled, and the trend showed no significant drop off, but rather a gradual decline after the treatment. Similarly, over the first two years after the refracture, the production increased 26,222 barrels of oil equivalent (BOE) (Shaefer 2006).

Similar results were found in the other three wells. Well B showed an increase from 241 to 349 Mscfd over the first 8 months after the treatment, while also seeing a 20,936 BOE increase over the first 20 months. For Well C, the incremental 20 month increase was 14,400 BOE, and for Well D, 14,123 BOE over a 21 month period (Shaefer 2006).

Although these wells were very successful, numerous wells will likely not have the same success. Estimates say that 85% of wells that can be successfully refractured are found in only 15-20% of the wells drilled (Sinha 2011). Wells that should not be looked at for refracturing are wells with questionable mechanical integrity, wells with low or inadequate reservoir quality, wells that are not productive after an already successful fracture treatment, or wells with thorough depletion in all its layers prior to the restimulation. However, there are qualities that signify that a well should be considered for refracturing, such as an inadequate initial fracture design or execution, better technology, better understanding of the reservoir, increase of oil and gas prices, which justifies the extra exploitation, and changes in reservoir stress that could potentially provide new production opportunities (Vincent 2010).

Refracturing is considered a good management practice because it not only increases production tremendously when successful, but because it is more environmentally friendly than the alternative solution for getting the oil and gas: drilling a new well. This saves surface area, truck traffic, and time the rig is running from not having to drill a new pad for a new well. Economically, it is a BMP because of the significantly increased production. Time is also saved in this instance, because there is no wait on having to drill, frac, complete, and then produce the well.

Closed-Loop Drilling and Fracturing

Currently a bill is proposed in the Marcellus shale region that could require closed-loop systems to be used in the hydraulic fracturing practice (Kuykendall 2011). Closed-loop drilling and fracturing systems take advantage of new technologies that allow for reuse of the drilling and fracturing fluid throughout the respective processes. This is accomplished by removing the solids from the fluid through mechanical and chemical means as it is pumped back to the surface. Once these solids are removed, the recycled fluid is stored in large, steel tanks until the next hydraulic fracturing job begins.

This environmentally friendly approach addresses several of the environmental issues pressing the industry. One concern that this approach reduces is chemical contamination of water supplies. In conventional fracture treatments, the waste water is sometimes stored in large, open pits on the surface rather than large steel tanks for long-term storage. If a storm were to come along or if one of the pits started leaking, it could be detrimental to the local surface and groundwater supplies. In closed-loop systems, however, the fluid has to be stored for longer periods of time, so the fluid is stored in large steel tanks. This greatly reduces the chances that harmful chemicals leak into the surface or groundwater after use in fracture treatments (Smith-Heavenrich 2008).

Another benefit is that the use of fresh water is greatly reduced in closed-loop systems because the fracturing fluid is recycled throughout the hydraulic fracturing process. According to EPA case studies in New Mexico, closed-loop systems could result in up to 80% reduction in total water usage. This would be great improvement compared to conventional methods (Smith-Heavenrich 2008).

With smaller volumes of water being used, the truck traffic in and out of the site is reduced. In the New Mexico case study, the EPA found that truck traffic was reduced by up to 75% for a given pad site throughout the entire drilling and fracturing process. This is a significant improvement, not only in traffic congestion, but more importantly in air emissions contributed by the oil and gas industry. With many major metropolitan areas entering or nearing EPA non-attainment for air quality, this has the potential to be a big step towards getting to or keeping air quality within acceptable standards (Smith-Heavenrich 2008).

Along with all of these environmental benefits, recycling also offers several other benefits. One major benefit is saved time. In the same New Mexico case study, between two similar wells in the same general area, the well that used a closed-loop system reportedly took only two-thirds of the time to complete compared to the well using conventional methods (Smith-Heavenrich 2008).

Wells that use closed-loop systems save $10,000 or more on average compared to those using conventional systems. This is due to less mileage on trucks, less water used, less time expended for the job to be completed, and reduced disposal costs. All of this adds up to major savings (Kuykendall 2011).

Closed-loop systems can also make jobs better in areas of safety, data acquisition, and process control. Safety is a major concern throughout the industry and any attempts to make jobs safer are immediately accepted. In closed-loop systems, because the fluid is immediately flowed back up the wellbore, information is immediately available concerning downhole conditions just by monitoring simple characteristics of the fluid, such as the pressure. This can be crucial in drilling and fracturing operations. The ability to monitor trends, predict what may happen downhole, and be proactive rather than reactive when safety risks are at hand provides a great advantage over current conventional methods. This same attribute allows for immediate data acquisition and process control because as soon as something happens downhole, it will likely appear in the fluid properties and can be handled immediately (Boutalbi 2011).

One item of interest that should be noted is that storing in steel tanks does not necessarily make the system closed loop. There are instances where the fracture fluid, after being pumped into the wellbore and recovered during flowback, is stored in steel tanks for the advantages listed above.

Pad Drilling

One of the key factors in the protection of the environment is reducing the surface area used by the drilling process. This process is in the best interest of companies and has seen significant advances in conventional drilling in the last 50 years. Through pad drilling, the amount of surface area used in fracturing operations can be reduced, lighter equipment can be used, and fewer roads for transport are required (Arthur 2009).

Pad drilling is a technology that centralizes multiple wellheads on a single pad. This technology uses modern directional drilling techniques to minimize the surface area while also reaching great depths in the subsurface. Special and careful considerations must be made to ensure proper anticollision procedures are in place. This is a critical task, but industry experience exists from offshore drilling, where small-footprint, multiwell drilling programs are the norm (Poedjono 2010).

The positive effects of pad drilling are different in different shale regions. In the Marcellus shale, the topographical features limiting hole locations as well as water disposal and supply issues present unique problems, and many operators are using multiwell pad drilling as a solution. In this major shale play, most drill sites are located on mountain tops that need to be cleared and leveled to begin operations. Operators have drilled as many as 14 wells on a single pad to be more efficient and be economically viable (Poedjono 2010).

However, in the Barnett Shale, this technology is used to reduce the amount of space taken up by the pad for a different reason. Due to the urban setting of the Barnett, the Dallas-Fort Worth area, the ability to drill multiple wells from a single pad site makes the play more accessible by allowing for less of the already limited surface area to be used per well (Pickett 2010).

Another study in the Horn River basin shale play showed successful results in using pad drilling. For the Horn River basin, the highest efficiency to that point was achieved while also having success in total cost, a 21% reduction in costs per completed interval. This proves that pad drilling is a good management practice that is applicable in many situations (Demong 2011).

Another element of pad drilling that contributes to environmentally friendly drilling as it relates to hydraulic fracturing is the amount of frac water used. Multiwell pad drilling can use recycled frac fluid within the pad, also known as closed-loop fracturing. Taking advantage of closed-loop and recycling systems, operators can use frac fluid for multiple wells and multiple stages without the added cost and environmental impacts of trucking recycled frac fluid between well sites or to storage locations between frac jobs.

Centralized Remote Fracturing

A practice that is used in combination with pad drilling is centralized fracturing. The concept is very similar to pad drilling, in that a recurring process is completed several times from a central location. This practice reduces the amount of truck traffic that comes through sites because the entire process is completed from one location. It can also be used in combination with pad drilling and/or closed-loop fracturing systems to significantly reduce the use of fresh water and further decrease the volume of truck traffic.

Centralized fracturing uses frac pumps located on remote, central pads that can pump frac water to remote sites. Lines are run from the pumps at the central pad to each individual well site. The pumps allow for pumping the frac fluids thousands of feet away from the central pad (“Optimizing” 2011). In some locations, it has even been recorded as fracturing up to 140 wells, even wells up to 3 miles away from the central location. Similar to other good management practices, centralized fracturing also reduces the time spent per well preparing for production (Pickett 2010).

The Williams Energy Services company is one that has had great success with centralized remote fracturing. In their studies, they have found that the time to drill and complete the well was reduced by up to 80%. They also found that for a single pad, truck traffic can be reduced by up to 30%, and for a site with several multiwell pads, up to 90% (Paules 2010). Williams’ success in being environmentally friendly has come not only from remote fracturing, but from a combination of it with pad drilling and closed-loop fracturing systems, which shows that environmentally friendly drilling practices in combination can be even more effective than when used separately (Williams 2007).

However, it should be noted that centralized fracturing may not be available in all situations, specifically when the geography of the region does not allow for it. One such situation is if there is a significant, steep incline anywhere along the path that the centralized fracture is to occur. This would hinder the flow rate and pressure of the fracture fluid as it is pumped to the location. There are also companies that have safety regulations that prevent this practice from being available. That said, where applicable, this practice is still considered an environmentally friendly practice.

Summary and Recommendations

Several potential environmental issues can be associated with hydraulic fracturing, including air emissions from truck traffic, high water usage, the use of dangerous chemicals in fracturing fluid, and the impact on nature from the size of pad sites. Several new technologies and good management practices that are considered environmentally friendly are also economically efficient and plausible.

- Closed-loop drilling and fracturing should be used for decreasing water usage, truck traffic and mileage, and to decrease the probability of spills of chemical fluids into surface and/or groundwater.
- With the hazardous chemicals used in hydraulic fracturing, it is imperative that the industry, environmental groups and regulators work together to find more environmentally friendly chemicals to use.
- Pad drilling should be used to decrease the amount of surface area taken by pad sites, which would decrease the impact on the nature around it and the overall landscape of the region.
- Centralized fracturing should be used to decrease the truck traffic that comes through locations by fracturing several wells from a single, remote pad location.
- Successful environmentally friendly operations often use combinations of good management practices.

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